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Early Identification of SE-Related Program Risks

Opportunities for DoD Systems Engineering (SE) Transformation
via SE Effectiveness Measures (EMs) and Evidence-Based Reviews

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14. ABSTRACT
DoD programs need effective systems engineering (SE) to succeed. DoD program managers need early warning of any risks to achieving effective SE. This SERC project has synthesized analyses of DoD SE effectiveness risk sources into a lean framework and toolset for early identification of SE-related program risks. Three important points need to be made about these risks. ? They are generally not indicators of "bad SE." Although SE can be done badly, more often the risks are consequences of inadequate program funding (SE is the first victim of an underbudgeted program), of misguided contract provisions (when a program manager is faced with the choice between allocating limited SE resources toward producing contract-incentivized functional specifications vs. addressing key performance parameter risks, the path of least resistance is to obey the contract), or of management temptations to show early progress on the easy parts while deferring the hard parts till later. ? Analyses have shown that unaddressed risk generally leads to serious budget and schedule overruns. ? Risks are not necessarily bad. If an early capability is needed, and the risky solution has been shown to be superior to the alternatives, accepting and focusing on mitigating the risk is generally better than waiting for a better alternative to show up. Unlike traditional schedule-based and event-based reviews, the SERC SE EM technology enables sponsors and performers to agree on the nature and use of more effective evidence-based reviews. These enable early detection of missing SE capabilities or personnel competencies with respect to a framework of Goals, Critical Success Factors (CSFs), and Questions determined by the EM task from the leading DoD early-SE CSF analyses. The EM tools enable risk-based prioritization of corrective actions, as shortfalls in evidence for each question are early uncertainties, which when combined with the relative system impact of a negative answer to the question, translates into the degree of risk that needs to be managed to avoid system overruns and incomplete deliveries.

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DoD program managers need early warning of any risks to achieving effective SE.

This SERC project has synthesized analyses of DoD SE effectiveness risk sources into a lean framework and toolset for early identification of SE-related program risks.

Three important points need to be made about these risks.

- They are generally not indicators of "bad SE." Although SE can be done badly, more often the risks are consequences of inadequate program funding (SE is the first victim of an underbudgeted program), of misguided contract provisions (when a program manager is faced with the choice between allocating limited SE resources toward producing contract-incentivized functional specifications vs. addressing key performance parameter risks, the path of least resistance is to obey the contract), or of management temptations to show early progress on the easy parts while deferring the hard parts till later.

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II. INTRODUCTION

The mission of the DoD Systems Engineering Research Center (SERC) is to perform research leading to transformational SE methods, processes, and tools (MPTs) that enable DoD and Intelligence Community (IC) systems to achieve significantly improved mission successes. In working with the DoD EM task sponsors, the EM team converged on a scope and direction of the research that has created and piloted a set of EM MPTs that has strong prospects for transforming the SE process into an evidence-based approach that enables early identification and resolution of program risks.

The major scope decisions worked out with the sponsors and their rationales are summarized in Table 1. For example, the original Statement of Work specified coverage of multiple system types: weapons platforms, systems of systems, and net-centric services; but converged on MDAPs, as these were the DoD programs most likely to benefit from improved SE EMs. Similarly, it focused on SE EMs common to ground, sea, air, and space systems rather than trying to cover them all. However, the EMs and tools are designed to be easy to extend to special domains by special-domain organizations. The development of prototype tools was performed both to facilitate pilot testing of the EM framework and questions, but also to provide an early demonstration that the SERC research could lead to the development of useful capabilities. Initially some sponsors were interested in research on the return on investment for specific SE practices, but we found insufficient data to support such analyses, and instead have structured the tools so that they could serve as ways to generate such data for the future. More detail on the evolution of the EM project's plans and schedules is provided in Appendix G.

Table 1. Summary of Major Scope Decisions

Decision	Rationale
• MDAP vs. multi-type EMs	• SE shortfalls a major MDAP problem
• Core vs. all-domain EMs	• Avoid numerous inapplicable EMs
• Ease of tailoring, extension	• Enable special-community tailoring
• Cover SE functional performance and personnel competency	• Sponsor priority
• Rate both degree of impact and degree of satisfaction evidence	• Relation to risk exposure RE=P(L)*S(L), ease of tailoring out zero-impact questions
• Hierarchical goal - critical success factor – question framework	• Ease of use, understanding; compatibility with related frameworks
• Compatibility with INCOSE Leading Indicators	• Complementary coverage: continuous vs. discrete; quantitative vs. qualitative
• Framework and tools	• Early SERC tangible product
• Pilot use and evaluation	• Evidence of strengths and shortfalls
• Initial focus on project assessment vs. practice ROIs	• ROI data unavailable; could be generated via tool use
• Initial focus on early SE	• Highest leverage on outcomes

Section III summarizes the overall methods, assumptions, and procedures used in the EM task. Section IV begins with an analysis of the DoD needs, opportunities, and business case for the use of SE EM methods, process, and tools (MPTs). It finds that the business case is very strong for large MDAPs, and not very strong for ad-hoc, quick-response system development. It then elaborates the detail of the SE EM framework and tools, the concepts of operation for their use, their use on pilot projects, and their analysis in comparison with the Defense Acquisition Program Support (DAPS) Methodology and its Systemic Analysis Database (SADB) of DAPS assessment results. It concludes that the evidence of utility and business-case return on investment is sufficient to proceed toward enabling their broad DoD use, subject to performing further research on the factors necessary to ensure the EM MPTs' scalability, extendability, and adaptability to change, and to performing the resulting improvements to the EM MPTs. It recommends a two-phase approach for achieving an initial operational capability and transitioning it to a sustaining organization. This would begin with research on approaches to the key issues, and continue with incremental elaboration, experimentation, and refinement of the preferred approaches.

III. METHODS, ASSUMPTIONS, AND PROCEDURES

A. Motivation and Context

Numerous General Accountability Office reports, Defense Science Board and National Research Council studies, and other studies have addressed the magnitude and frequency of DoD MDAP budget and schedule overruns and delivery deficiencies. Many of these have identified inadequate SE as a major source of the problems. Further analyses have found that these SE inadequacies have largely resulted from commitments to proceed based on inadequate evidence that the proposed system solutions can actually meet DoD needs within DoD's operational environment and within the program's available budget and schedule resources.

This research project was commissioned by the SERC sponsors to identify and organize a framework of SE effectiveness measures (EMs) that could be used to assess the evidence that a MDAP's SE approach, current results, and personnel competencies were sufficiently strong to enable program success. Another component of the research was to formulate operational concepts that would enable MDAP sponsors and performers to use the EMs as the basis of collaborative formulation, scoping, planning, and monitoring of the program's SE activities, and to use the monitoring results to steer the program toward the achievement of feasible SE solutions.

B. Technical Approach

The EM research project reviewed over two-dozen sources of candidate SE EMs, and converged on the strongest sources to be used to identify candidate SE EMs. We developed a coverage matrix to determine the envelope of candidate EMs, and the strength of consensus on each candidate EM. It fed the results back to the source originators to validate the coverage matrix results. This resulted in further insights and added candidate EMs to be incorporated into an SE Performance Risk Framework. The resulting framework is organized into a hierarchy with 4 Goals, 18 Critical Success Factors, and 74 Questions that appeared to cover the central core of common SE performance determinants of SE effectiveness.

Concurrently, the research project was extended to also assess SE personnel competency as a determinant of program success. We analyzed an additional six personnel competency risk frameworks and sets of questions. Their Goals and Critical Success Factors were very similar to those used in the SE Performance Risk Framework, although the Questions were different. The resulting SE Competency Risk Framework added one further Goal of Professional and Interpersonal Skills with five Critical Success Factors, resulting in a framework of 5 Goals, 23 Critical Success Factors, and 81 Questions.

In order to evaluate the SE Performance and Competency Risk Frameworks, we developed simple, easy-to-use spreadsheet tools for pilot projects to use and provide feedback on the utility of the frameworks and tools. The tools are called the SE Performance Risk Tool (SEPRT) and the SE Competency Risk Tool (SECRT). The initial round of 7 pilot projects yielded quite positive overall assessment result, as discussed in Sections IV.B.5 and IV.D. It also provided several valuable suggestions for improvement, some of which have already been implemented.

We performed a complementary analysis comparing the coverage of the SE EMs with the content of the DAPS Methodology, and with respect to the initial results of queries to the Systemic Analysis Database

(SADB) of negative findings resulting from DAPS assessments. The results again were largely positive, as discussed in Section IV.E. Overall, the DAPS Methodology goes into greater detail in its questions, providing a complementary capability for users of the SEPRT and SECRT to apply in focusing in on their high-impact questions.

We developed operational concepts for the use of the SEPRT and SECRT on MDAPs for three early life cycle stages. Each involves collaborative efforts by the program sponsors and performers. For each question, the sponsors rate the relative impact on the program if the answer is negative, and a scale of Critical (40-100% overrun or its equivalent in delivery shortfalls); Significant (20-40% overrun); Moderate (2-20% overrun); and Little or No Impact (0-2% overrun). These ratings are provided to the performers, who identify situations in which the ratings appear inconsistent with the program's objectives, available resources, contract provisions, or likely system impact. These situations stimulate constructive discussion and a more compatible shared vision and feasible set of impact ratings and program parameters to be used in managing the program.

Once consensus is reached on the impact ratings, the performer SEs proceed to define and develop the system, along with evidence that the questions are being satisfactorily addressed. The evidence is evaluated by independent experts at each major review. Shortfalls in evidence are identified as uncertainties and risk probabilities, which when combined with the question's risk impact determine the level of risk exposure associated with the question. To reinforce the importance of the evidence-based assessments, a considerable portion of the performer's award fee is based on the degree to which the performer evidence has shown the project to be at a low level of risk.

The evidence is thus a first-class deliverable, as compared to being an optional appendix in most current programs, whose content is largely dropped as project resources become scarce. As such, its development needs to be planned, budgeted, and made a key element in the project's earned value management system. Any risks resulting from shortfalls in evidence need to be addressed by risk mitigation plans and their associated resource requirements. Both evidence generation and risk mitigation add up-front effort, but a business case analysis of the effects of going from minimal to thorough architecture and risk resolution on 161 software-intensive systems yields significant returns on investment for MDAP-scale projects, as discussed in Section IV.A.3.

IV. RESULTS AND DISCUSSION

This section begins with a summary of the DoD needs for improvements in overall systems acquisition, and particularly in systems engineering. One of the particular needs in DoD systems engineering is for better ways for measuring its effectiveness, as it is difficult to manage something that one is not able to measure. A particular opportunity is for SE EMs that focus on measurable and independently verifiable evidence of effectiveness, and associated evidence-based reviews that enable MDAPs to identify shortfalls in evidence of the feasibility of the specifications and plans being presented for approval at milestone reviews. This opportunity led us to associate the SE EMs with operational concepts highlighting their use in evidence-based reviews. Section A also presents a business case for the thoroughness of SE activities, which shows that the payoff for evidence-based SE EMs is greatest for large MDAPs.

Section B proceeds to describe the derivation of the SE EM frameworks of Goals, Critical Success Factors, and Questions for performance and personnel competency from leading DoD studies. It then describes the *Systems Engineering Performance Risk Tool* (SEPRT) and *Systems Engineering Competency Risk Tool* (SECRT) tools developed to support pilot evaluation of the SE EM frameworks, and then summarizes the results of the pilot studies. Section C then presents several operational concepts for using the tools, both at major DoD milestones and during planning and execution of DoD MDAP projects. Section D provides a more detailed summary of two of the pilot evaluations, and Section E summarizes a complementary evaluation of the framework via its comparison to the DoD Defense Acquisition Program Support (DAPS) methodology and its associated Systemic Analysis Database (SADB) of DAPS program assessment results.

Section F summarizes the conclusions that the business case, the pilot results, and the DAPS and SADB comparison results all point to a strong payoff for DoD use of the SE SM framework, tools, and evidence-based concepts of operation. It also provides recommendations for a two-phase approach for achieving an initial operational capability and transitioning it to a sustaining organization. This would begin with research on approaches to the key issues, and continue with incremental elaboration, experimentation, and refinement of the preferred approaches.

A. DoD MDAP SE EM Needs, Opportunities, and Business Case

1. The Need and Opportunity

Table 2, obtained from a recent General Accountability Office (GAO) report [29], shows the magnitude of the problems to be addressed by the SE EM capabilities. These included total DoD annual MDAP cost growths of roughly $300 billion per year and delivery delays coming close to two years. In many cases, these "cost and schedule growths" were not actual growths, but the results of traditional acquisition practices requiring programs to associate costs and schedules with capabilities before evidence of technical, cost, and schedule feasibility was available.

Table 2. Analysis of U.S. Defense Dept. Major Defense Acquisition Program Portfolios

Analysis of U.S. Defense Department Major Defense Acquisition Program Portfolios			
Fiscal 2009 dollars			
Portfolio size	**2003**	**2007**	**2008**
Number of programs	77	95	96
Total planned commitments	$1.2 trillion	$1.6 trillion	$1.6 trillion
Commitments outstanding	$724.2 billion	$875.2 billion	$786.3 billion
Portfolio indicators			
Change to total RDT&E* costs from first estimate	37%	40%	42%
Change to total acquisition costs from first estimate	19%	26%	25%
Total acquisition cost growth	$183 billion	$301.3 billion	$296.4 billion
Share of programs with 25% increase in program acquisition unit cost growth	41%	44%	42%
Average schedule delay in delivering initial capabilities	18 months	21 months	22 months
Source: U.S. Government Accountability Office **Research, Development, Testing & Evaluation*			

Providing such validated evidence is generally considered to be a good practice, but generally fails to be done well. This is because of a lack of evidence criteria; a lack of evidence-generation procedures and measures for monitoring evidence generation; a lack of appreciation of the consequences of proceeding into development with unsubstantiated specifications and plans; and because of current methods, standards, and contractual provisions that make evidence generation optional. The main contributions of the SERC SE EM task are to provide experience-based approaches for each of these concerns and to illustrate the consequences of their use via case studies and parametric analysis.

2. Evidence Shortfalls in Current SE Practices

2.1 Technical Shortfalls

Current system design and development methods focus strongly on the inputs and outputs, preconditions and post-conditions that a system function, component, or service operates by as a product. They lack adequate capabilities to support evidence about how well the elements perform, how expensive they will be to develop, or how compatible are their underlying assumptions. In principle, they support reasoning about off-nominal performance, but in practice their descriptions generally focus on sunny-day scenarios. As a result, many DoD MDAP project reviews tend to focus on exhaustive presentations of PowerPoint charts and Unified Modeling Language (UML) diagrams. They provide little evidence that the system they describe could handle rainy-day scenarios; perform adequately on throughput, response time, safety, security, usability, or other desired quality attributes across a range of representative mission scenarios; be buildable within the available budgets and schedules in the plan; or generate positive returns on investment for the stakeholders.

Figure 1 shows a summary from a 2007 National Defense Industrial Association (NDIA) workshop of analyzing the underlying causes of the negative findings of DAPS reviews of several dozen DoD programs. It shows that two of the top four causes of negative findings were due to SE shortfalls in technical processes and requirements processes, shown in bold. Several others, shown in italics, were partly due to inadequate SE performance, often caused by the fact that adequate SE is the first victim of a lack of program realism with respect to the necessary budgets and schedules needed to do a thorough job.

SE Performance, Competency are Major Sources of OSD/AT&L Systemic Analysis Negative Findings

1 **Technical process (35 instances)**	6 *Lack of appropriate staff (23)*
- V&V, integration, modeling & sim.	
2 Management process (31)	7 Ineffective organization (22)
3 Acquisition practices (26)	8 *Ineffective communication (21)*
4 **Requirements process (25)**	9 *Program realism (21)*
5 *Competing priorities (23)*	10 *Contract structure (20)*

Figure 1. Analysis of Negative Findings of DAPS Reviews

2.2 Management Shortfalls

A major recent step forward in the management of outsourced government projects has been to move from schedule-based reviews to event-based reviews. A schedule-based review says basically that: “The contract specifies that the Preliminary Design Review (PDR) will be held on June 1, 2011, whether we have a design or not.”

In general, neither the customer nor the developer wants to fail the PDR, so the project goes into development with the blessing of having passed a PDR, but with numerous undefined interfaces and unresolved risks. As shown below, these will generally result in major project overruns and incomplete deliveries.

An event-based review says: “Once we have a preliminary design, we will hold the PDR.” Such a review will generally consist of exhaustive presentations of sunny-day PowerPoint charts and UML diagrams. This is largely because most traditional DoD acquisition contracts and procedures have an early focus on product-oriented versus feasibility-evidence-oriented deliverables and reviews.

These reinforce paths toward project disaster, as in this quote from a recent large-project manager: “I’d like to have some of my systems engineers address those software quality-factor risks, but my contract deliverables and award fees are based on having all of the system’s functions defined by the next review.” Similar over-focus on product definition is found in project earned-value management systems for tracking project progress and Data Item Descriptions (DIDs) for deliverables. Most contract DIDs cover function, interface, and infrastructure considerations, but place demonstration of their feasibility in optional appendices where, as with the project manager above, they are the first to go when time and effort are running out.

3. Consequences of Evidence Shortfalls

This is not just a DoD problem, but a pervasive problem in system acquisition and outsourcing. For example, the biannual Standish Reports consistently identify shortfalls in evidence of feasibility with respect to stakeholder objectives as the major root causes of project failure. The 2009 Standish Report [29] found that only 32% of the 9000 projects reported delivered their full capability within their budget and schedule; 24% were cancelled; and 44% were significantly over budget, over schedule, and/or incompletely delivered. More detail on the top critical success factors distinguishing successful from failed software projects was in the 2005 Standish Report. There, 71% of the sources of failure were primarily due to evidence shortfalls with respect to stakeholder objectives (lack of user involvement, executive support, clear requirements, proper planning, and realistic expectations).

Recent further analyses of the Constructive Cost Model (COCOMO) II database on the effects of incomplete architecture definition, risk resolution, and resulting feasibility evidence on software-intensive systems are shown in Figure 2. They show the results of a risk-driven "how much architecting is enough?" analysis, based on the COCOMO II Architecture and Risk Resolution (RESL) factor [8], [13]. This factor was calibrated along with 22 others to 161 project data points. It relates the amount of extra rework effort on a project to the degree of evidence that the project had demonstrated its architecture feasibility and resolved its technical and management risks. This also correlates with the percent of project effort devoted to software-intensive system architecting and risk resolution.

Figure 2. Architecture Evidence Shortfall Penalties and Resulting Architecting Investment Sweet Spots

The analysis indicated that the amount of rework was an exponential function of project size. A small (10 thousand equivalent source lines of code, or KSLOC) project could fairly easily adapt its architecture to rapid change via refactoring or its equivalent, with a rework penalty of 18% between minimal and extremely thorough architecture and risk resolution. However, a very large (10,000 KSLOC) project would incur a corresponding rework penalty of 91%, covering such effort sources as integration rework due to undiscovered large-component interface incompatibilities, technology immaturities, and critical performance shortfalls.

The effects of rapid change (volatility) and high dependability (criticality) on the architecture evidence shortfall penalties and resulting architecting investment sweet spots are shown in the right hand graph. Here, the solid black lines represent the average-case cost of rework, architecting, and total cost for a 100-KSLOC project as shown at the left. The dotted red lines show the effect on the cost of architecting and total cost if rapid change adds 50% to the cost of architecture and risk resolution. Quantitatively, this moves the sweet spot from roughly 20% to 10% of effective architecture investment (but actually 15% due to the 50% cost penalty). Thus, high investments in architecture, feasibility analysis, and other documentation do not have a positive return on investment for very high-volatility projects due to the high costs of documentation rework for rapid-change adaptation.

The dashed blue lines at the right represent a conservative analysis of the cost effects of system failure due to unidentified architecting shortfalls. It assumes that the costs of architecting shortfalls are not only added rework, but also losses to the organization's operational effectiveness and productivity. These are conservatively assumed to add 50% to the project-rework cost of architecture shortfalls to the organization. In most cases for high-assurance systems, the added cost would be considerably higher.

Quantitatively, this moves the sweet spot from roughly 20% to over 30% as the most cost-effective investment in architecting and development of feasibility evidence for a 100-KSLOC project. It is good to note that the "sweet spots" are actually relatively flat "sweet regions" extending 5-10% to the left and right of the "sweet spots." However, moving to the edges of a sweet region increases the risk of significant losses if some project assumptions turn out to be optimistic.

The bottom line for Figure 2 is that the greater the project's size, criticality, and stability are, the greater is the need for validated architecture feasibility evidence. However, for very small, low-criticality projects with high volatility, the evidence-producing efforts would make little difference and would need to be continuously redone, producing a negative return on investment. In such cases, agile methods such as rapid prototyping, Scrum [27] and eXtreme Programming [3] will be more effective. Overall, evidence-based specifications and plans are a much better match to MDAPs, where in general they will eliminate many of the system delivery overruns and shortfalls experienced on current MDAPs.

B. DoD MDAP SE EM Framework and Tools: SEPRT and SECRT

Our research suggests that systems engineering (SE) effectiveness measures (EMs) can be characterized along two major dimensions of risk, and across two timescales. SE effectiveness can be assessed both by the *performance* of the SE function, and by the *competency* of those performing it. Each dimension can be evaluated at *discrete* decision points in a program, and also in a *continuous* fashion throughout its execution.

We propose three frameworks to evaluate SE EMs along these dimensions and timescales, and have created prototype tools to evaluate two of these frameworks in the discrete dimension: the *Systems Engineering Performance Risk Tool* (SEPRT), and the *Systems Engineering Competency Risk Tool* (SECRT). Complementing these discrete-evaluation frameworks, research by INCOSE on continuous evaluation has led to conceptual development of a set of *leading indicators* (LI), which were included as candidates in developing the SEPRT performance evaluation questions (See Table 3.)

Table 3. Dimensions and timescales of EM evaluation

Discrete	SEPRT	SECRT
Continuous	INCOSE Leading Indicators	
	Performance	**Competency**

This section discusses the evolution of the SE EM evaluation frameworks, and the specific implementations of these frameworks into the prototype SEPRT and SECRT tools. We also present preliminary results of pilot evaluations of the SEPRT and SECRT tools, which were developed to help determine the utility of the proposed EM frameworks across multiple acquisition frameworks and application domains.

1. SEPRT and SECRT Goal-Critical Success Factor-Question Framework

Our initial research focused on identifying methods that might be suitable for assessing the effectiveness of systems engineering on major defense acquisition programs (MDAPs). A literature review identified eight candidate measurement methods, as follows:

- NRC Pre-Milestone A & Early-Phase SysE top-20 checklist [20]
- Air Force Probability of Program Success (PoPS) Framework [1]
- INCOSE/LMCO/MIT Leading Indicators [24]
- Stevens Leading Indicators (new; using SADB root causes) [34]
- USC Anchor Point Feasibility Evidence progress [31]
- UAH teaming theories [14]
- NDIA/SEI capability/challenge criteria [15]
- SISAIG Early Warning Indicators [9] / USC Macro Risk Tool [33]

Pages 5-8 of the NRC report [20] suggests a “Pre-Milestone A/B Checklist” for judging the successful completion of early-phase systems engineering. Using this checklist as a concise starting point, the researchers identified similar key elements in each of the other candidate measurement methods, resulting in a list of 44 characteristics of effective systems engineering (see Appendix C). Multiple research teams independently examined two or more candidate EMs to assess whether and to what degree each characteristic was addressed by the respective measure, as noted in Table 4. This assessment also identified another six EM characteristics not previously noted.

Table 4. Review of candidate EMs by research teams

Candidate EM	USC	Stevens	FC-MD	UAH
PoPS Leading Indicators (LIs)	X	X		X
INCOSE LIs	X		X	
Stevens LIs	X	X	X	
SISAIG LIs/ Macro Risk	X		X	X
NRC Top-20 List	X		X	X
SEI CMMI-Based LIs	X	X		X
USC AP-Feasibility Evidence	X	X	X	
UAH Team Effectiveness	X	X		X

Previous research by the USC team into a macro-risk model for large-scale projects had resulted in a taxonomy of high-level goals and supporting critical success factors (CSFs) based on [28]. This was identified as a potential framework for organizing the 51 EM characteristics identified above. Analysis of the characteristics showed that they could be similarly organized into a series of four high-level goals, each containing 4-5 CSFs, as seen in Table 5. Our survey of the existing literature suggests that these CSFs are among the factors that are most critical to successful SE, and that the degree to which the SE function in a program satisfies these CSFs is a measure of SE effectiveness.

Table 5. Goals and CSFs for SE performance

High-level Goals	Critical Success Factors
Concurrent definition of system requirements & solutions	Understanding of stakeholder needs
	Concurrent exploration of solutions
	System scoping & requirements definition
	Prioritization/allocation of requirements
System life-cycle organization, planning & staffing	Establishment of stakeholder RAAs
	Establishment of IPT RAAs
	Establishment of resources to meet objectives
	Establishment of selection/contracting/incentives
	Assurance of necessary personnel competencies
Technology maturing & architecting	COTS/NDI evaluation, selection, validation
	Life-cycle architecture definition & validation

High-level Goals	Critical Success Factors
	Use of prototypes, models, etc. to validate maturity
	Validated budgets & schedules
Evidence-based progress monitoring & commitment reviews	Monitoring of system definition
	Monitoring of feasibility evidence development
	Monitoring/assessment/re-planning for changes
	Identification and mitigation for feasibility risks
	Reviews to ensure stakeholder commitment

Related to the effectiveness measures of SE performance is the need to measure the effectiveness of the staff assigned to the SE function. Besides the eight SEPRT sources, six additional sources were reviewed for contributions to Personnel Competency evidence questions. These were:

- Office of the Director of National Intelligence (ODNI), Subdirectory Data Collection Tool: Systems Engineering [22]
- INCOSE Systems Engineering Handbook, August 2007 [17]
- ASN (RD&A), Guidebook for Acquisition of Naval Software Intensive Systems, September 2008 [3]
- CMU/SEI, Models for Evaluating and Improving Architecture Competence [4]
- NASA Office of the Chief Engineer, NASA Systems Engineering Behavior Study, October 2008 [34]
- National Research Council, Human-System Integration in the System Development Process, 2007 [23]

These were analyzed for candidate knowledge, skills, and abilities (KSA) attributes proposed for systems engineers. Organizing these work activities and KSAs revealed that the first four goals and their CSFs were in common with the EM taxonomy. An additional goal and its related CSFs were also discovered, as presented in Table 6.

Table 6. Additional goals and CSFs for SE competency

High-level Goal	Critical Success Factors
Professional and interpersonal skills	Ability to plan, staff, organize, team-build, control, and direct systems engineering teams
	Ability to work with others to negotiate, plan, execute, and coordinate complementary tasks for achieving program objectives
	Ability to perform timely, coherent, and concise verbal and written communication
	Ability to deliver on promises and behave ethically
	Ability to cope with uncertainty and unexpected developments, and to seek help and fill relevant knowledge gaps

2. Question Impact/Evidence Ratings and Project SE Risk Assessment

Using these relatively high-level criteria, however, it is difficult to evaluate whether the SE on a particular program adequately satisfies the CSFs. In its approach to evaluating macro-risk in a program, [31] suggests that a goal-question-metric (GQM) approach. [4] provides a method to accomplish this evaluation. Following this example, the researchers developed *questions* to explore each goal and CSF, and devised *metrics* to determine the relevance of each question and the quality of each answer.

The researchers began question development for the SE performance framework with the checklist from [20]. Further questions were adapted from the remaining EM characteristics, rewritten as necessary to express them in the form of a question. Each question is phrased such that, answered affirmatively, it indicates positive support of the corresponding CSF. We hypothesize that the strength of support for each answer is related to the relative *risk probability* associated with the CSF that question explores.

Rather than rely simply on the opinion of the evaluator as to the strength of the response, a more quantifiable *evidence-based* approach was selected. The strength of the response is related to the amount of evidence available to support an affirmative answer—the stronger the evidence, the lower the risk probability. Feedback from industry, government, and academic participants in workshops conducted in March and May 2009 suggested that a simple risk probability scale with four discrete values be employed for this purpose.

Evidence takes whatever form is appropriate for the particular question. For example, a simulation model might provide evidence that a particular performance goal can be met. Further, the strongest evidence is that which independent expert evaluators have validated.

Recognizing that each characteristic might be more or less applicable to a particular program being evaluated, the questions are also weighted according to the *risk impact* that failure to address the question might be expected to have on the program. Again based on workshop feedback, a four-value scale for impact was chosen.

The product of the magnitude of a potential loss (the risk impact) and the likelihood of that loss (the risk probability) is the *risk exposure*. Although risk exposure is generally calculated given quantitative real-number estimates of the magnitude and probabilities of a loss, the assessments of risk impact and risk probability described above use an ordinal scale. Therefore, we employ a mapping between the four-value risk probability and risk impact scales to a discrete five-value risk exposure.

3. Prototype SE Effectiveness Risk Tools

As a means to test the utility of these characteristics for assessing systems engineering effectiveness, using the GQM approach outlined above, the researchers created prototype tools that might be used to perform periodic evaluations of a project, similar to a tool used in conjunction with the macro-risk model described above. The following section describes this prototype implementation in further detail.

3.1 SE Performance Risk Tool

The Systems Engineering Performance Risk Tool (SEPRT) is an Excel spreadsheet-based prototype focused on enabling projects to determine their relative risk exposure due to shortfalls in their SE performance relative to their prioritized project needs. It complements other SE performance effectiveness assessment capabilities such as the INCOSE Leading Indicators, in that it supports periodic assessment of evidence of key SE function performance, as compared to supporting continuous assessment of key project SE quantities such as requirements volatility, change and problem closure times, risk handling, and staffing trends.

The operational concept of the SEPRT tool is to enable project management (generally the Project Manager or his/her designate) to prioritize the relative impact on the particular project of shortfalls in performing the SE task represented in each question. Correspondingly, the tool enables the project systems engineering function (generally the Chief Engineer or Chief Systems Engineer or their designate) to evaluate the evidence that the project has adequately performed that task. This combination of impact and risk assessment enables the tool to estimate the relative project risk exposure for each question, and to display them in a color-coded Red-Yellow-Green form.

These ideas were reviewed in workshops with industry, government, and academic participants conducted in March and May 2009, with respect to usability factors in a real project environment. A consensus emerged that the scale of risk impact and risk probability estimates should be kept simple and easy to understand. Thus a red, yellow, green, and grey scale was suggested to code the risk impact; and a corresponding red, yellow, green, and blue scale to code the risk probability. These scales are discussed in more depth below. An example of the rating scales, questions, and calculated risk exposure in the prototype tool is presented below.

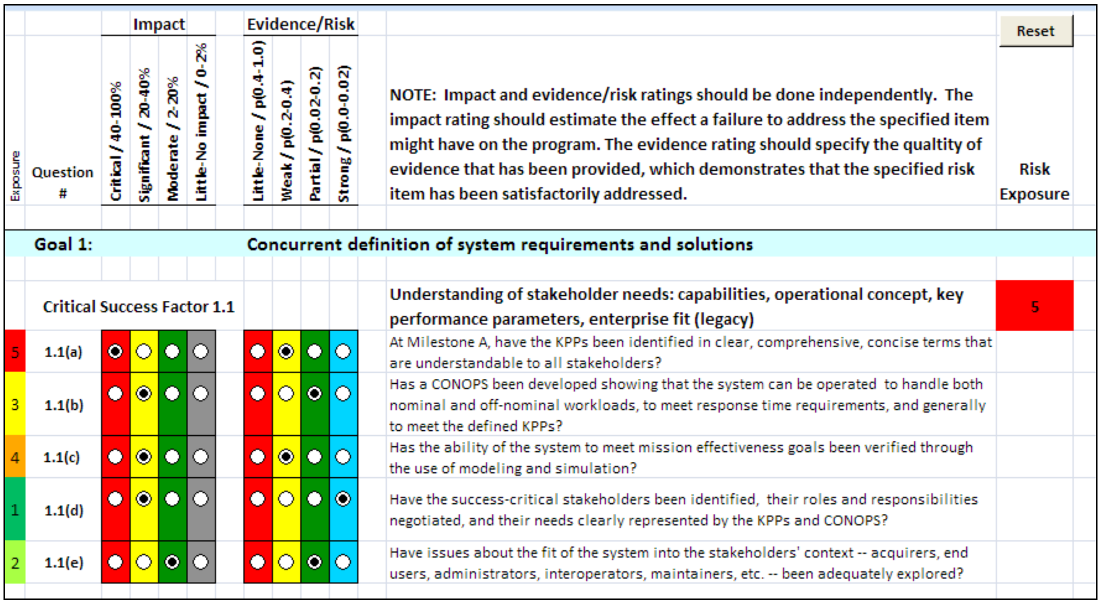


Figure 3. Example of SEPRT prototype

Risk impact ratings vary from a *critical impact* of shortfalls in performing the SE task in question (red) through *significant impact* (yellow) and *moderate impact* (green) to *little-no impact* (gray), as illustrated in Table 7. These relative impact ratings enable projects to tailor the evaluation to the project's specific situation. Thus, for example, it is easy to "drop" a question by clicking on its "No Impact" button, but also easy to restore it by clicking on a higher impact button. The rating scale for the impact level is based on the user's chosen combination of effects on the project's likely cost overrun, schedule overrun, and missing percent of promised over actual delivered capability (considering there are various tradeoffs among these quantities).

Table 7. Risk impact ratings

Rating	Cost/Schedule/Capability Shortfall
Little-No impact (Gray)	0-2% (1% average)
Moderate impact (Green)	2-20%(11% average)
Significant impact (Yellow)	20-40% (30% average)
Critical impact (Red)	40-100% (70% average)

Using Question 1.1(a) from Figure 3 as an example, if the project were a back-room application for base operations with no mission-critical key performance parameters (KPPs), its impact rating would be Little-No impact (Gray). However, if the project were a C4ISR system with several mission-critical KPPs, its rating would be Critical impact (Red).

The Evidence/Risk rating is the project's degree of evidence that each SE effectiveness question is satisfactorily addressed, scored (generally by the project Chief Engineer or Chief Systems Engineer or their designate) on a risk probability scale: the less evidence, the higher the probability of shortfalls. The evaluator chooses a rating based on the probability of an unsuccessful outcome in performing the SE task in question, as noted in Table 8

Table 8. Risk probability/evidence ratings

Likelihood of Shortfall	Degree of evidence	Probability Range
High probability (Red)	Little-no evidence	P = 0.4 - 1.0; average 0.7
Medium probability (Yellow)	Weak evidence	P = 0.2- 0.4; average 0.3
Low probability (Green)	Partial evidence	P = 0.02 – 0.2; average 0.11
Very Low probability (Blue)	Strong and externally validated evidence	P = 0 – 0.02; average 0.01

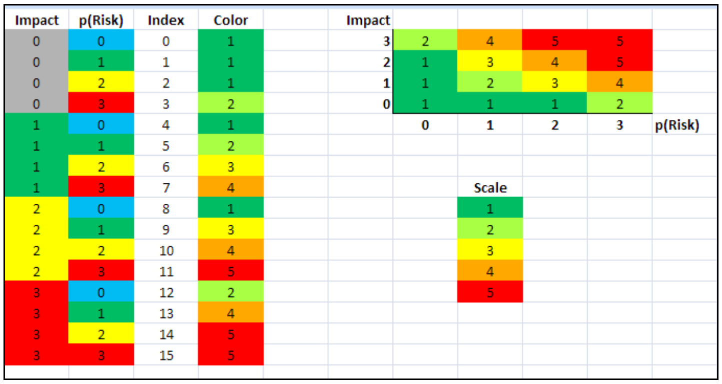
Again, using Question 1.1(a) from Figure 3 as an example analyzing a C4ISR system with several mission-critical KPPs, then a lack of evidence (from analysis of current-system shortfalls and/or the use of operational scenarios and prototypes) that its "KPPs had been identified at Milestone A in clear, comprehensive, concise terms that are understandable to the users of the system" would result in a High risk probability, while strong and externally validated evidence would result in a Very Low risk probability.

Using the average probability and impact values from Table 7 and Table 8, the relative Risk Exposure = P(Risk) * Size(Risk) implied by the ratings is presented in Table 9.

Table 9. Average risk exposure calculation

Impact // Probability	Very Low	Low	Medium	High
Critical	0.7	7.7	21	49
Significant	0.3	3.3	9	21
Moderate	0.11	1.21	3.3	7.7
Little-No Impact	0.01	0.11	0.3	0.7

The prototype tool provides a customizable mapping of each impact/probability pair to a color-coded risk exposure, based on the above table. For each question, the *risk exposure* level is determined by the combination of risk impact and risk probability, and a corresponding risk exposure color-coding is selected, which ranges from red for the highest risk exposure to green for the lowest. Figure 4 provides an example of this mapping from the prototype tool, and illustrates the resulting risk exposure matrix for the selected mapping.



Impact	p(Risk)	Index	Color
0	0	0	1
0	1	1	1
0	2	2	1
0	3	3	2
1	0	4	1
1	1	5	2
1	2	6	3
1	3	7	4
2	0	8	1
2	1	9	3
2	2	10	4
2	3	11	5
3	0	12	2
3	1	13	4
3	2	14	5
3	3	15	5

Impact					
3	2	4	5	5	
2	1	3	4	5	
1	1	2	3	4	
0	1	1	1	2	
	0	1	2	3	p(Risk)

Scale
1
2
3
4
5

Figure 4. Impact/risk mapping to risk exposure

The current tool assigns the highest (red) risk exposure for the (Impact, Probability) combinations of (Critical, Medium), (Critical, High), and (Significant, High). It assigns a medium-high (orange) risk exposure for the (Impact, Probability) combinations of (Critical, Low), (Significant, Medium), and (Moderate, Medium). A medium (yellow) risk exposure is assigned for the (Impact, Probability) combinations of (Significant, Low), and (Moderate, Medium). A medium-low (green) risk exposure results from the (Impact, Probability) combinations of (Critical, Very Low), (Moderate, Low), and (Little-No, High). Finally, all remaining combinations involving Little-No impact or Very Low probability are assigned the lowest risk exposure (green).

As seen in Figure 3, the risk exposure resulting from scoring the impact and risk of each question is presented in the leftmost column. Based on suggestions from workshop participants, the current version of the tool assigns the highest risk exposure level achieved by any of the questions in a CSF as the risk exposure for the overall CSF. This maximum risk exposure presented in the rightmost column for the CSF. This rating method has the advantages of being simple and conservative, but might raise questions if, for example, CSF 1.1 were given a red risk exposure level for one red and four greens, and a yellow risk exposure level for five yellows. Experience from piloting of the tool has suggested refinements to this approach, discussed later in this report.

3.2 SE Competency Risk Tool

The Systems Engineering Competency Risk Tool (SECRT), like the SEPRT tool described above, is a prototype expression of the framework for evaluating SE competency. Although the framework is believed to be complete, the question set supporting the framework is not based on a coverage matrix analysis, but largely based on the SEPRT framework plus the additional goal and five CSFs addressing Professional and Interpersonal Skills. SECRT's concise, project-tailorable content complements other more detailed SE personnel competency frameworks that focus more on SE personnel certification or organizational skills coverage.

The general design of the SECRT prototype is identical to that of SEPRT—an Excel-based spreadsheet. The SECRT impact and evidence scales are the same as SEPRT, except that the ratings for evidence score the relative experience and competency of the team needed to fulfill the SE function. This scale reflects the team's composite experience and competency level with respect to its relevant systems engineering technical, professional, and applications domain knowledge, skills, and abilities. Similar to

SEPRT, the SECRT evidence ratings range from a High probability of an unsuccessful outcome in performing the SE task in question (red; no relevant experience and competency), through Medium probability (yellow; some relevant experience and competency) and Low probability (green; good relevant experience and competency), to very low probability of an unsuccessful outcome (blue; expert relevant experience and competency).

The following sections describe and use the SEPRT tool as an example, though the discussion applies equally to the SECRT tool. It is expected that the SECRT framework will continue to evolve and mature in future research.

4. Description and Usage of Prototype Tools

The prototype Systems Engineering Performance Risk Tool (SEPRT) and Systems Engineering Competence Risk Tool (SECRT) tools are extendable Excel spreadsheets organized around a framework of systems engineering goals, contributing critical success factor questions, and detailed metric questions. Each question can be prioritized for relevance to the particular systems engineering effort, and assessed with respect to the degree of evidence that it is being well addressed.

The tools are intended for use at discrete assessment points during a project's lifetime. For example, the tools might be used to review SE plans or preparations for major milestone reviews to assess any shortfalls in SE effectiveness. The SEPRT tool addresses the evidence of thoroughness with which core systems engineering functions are being performed. The SECRT tool assesses the evidence of whether sufficient SE team personnel competence is in place to carry out the functions. Both tools treat a shortfall in evidence as an increased risk probability. This probability, multiplied by the relative impact of the item on project success, produces a risk exposure quantity, color-coded for identification of the risk levels of SE effectiveness items.

The primary objective of piloting the prototype tools is to determine the utility of the evaluation frameworks at various points in a project's life cycle, across different acquirers and application domains. Data of interest from piloting these tools includes both the cost in effort required to perform the assessments, and the value obtained from performing them. It is not an objective of the pilot evaluations for evaluators to externally disclose shortfalls or risks in the projects assessed, although the researchers are seeking information on the effects of using the tools.

4.1 Tool Overview

The SEPRT and SECRT tools are Excel-based prototypes. The tools were created in Excel 2007. Users with Excel 2003 will have the same functionality, but the risk exposure color-coding does not function. Macros must be enabled for functionality. The SECRT competency evaluation tool operates identically to the SEPRT tool described below, though the critical success factors and evaluation questions differ.

Each tool identifies high-level Goals that must be met, and provides four or five Critical Success Factors that support each goal. Questions then explore whether the critical success factors are being met. Each question is evaluated against two separate scales: *evidence* and *impact*. Less evidence is equated to higher risk. An impact rating for each question allows the evaluator to adjust the weighting of the question for that particular project.

It is recommended that the impact rating and evidence scores be determined by independent reviewers. For instance, the project or program manager or their designate might provide the impact ratings, and project chief engineer or chief systems engineer or their designate might provide the evidence ratings.

Figure 5 illustrates the rating scale for impact and evidence on each question. In the leftmost set of selections, the evaluator selects an appropriate weighting for the impact, ranging from Critical impact (red) to Little-No impact (gray). Similarly, the rightmost selection set indicates the degree of evidence available that supports the evaluation of each question, where red implies little-or-no evidence has been found to support the conjecture, and blue implies that independent experts have validated the evidence. Users make selections by clicking on the appropriately colored boxes for each question.

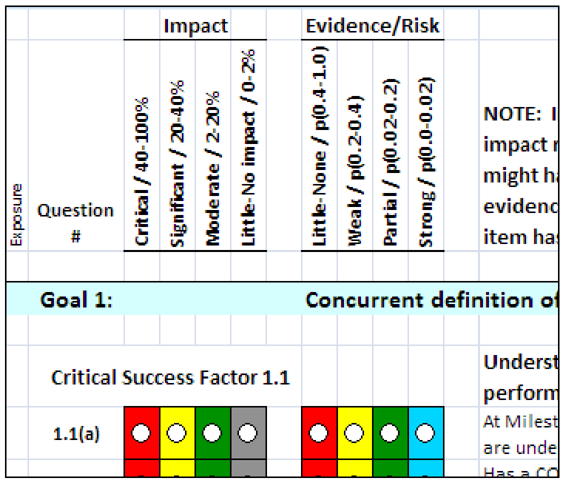


Figure 5. Detail of impact and evidence rating

As seen in Figure 6, the impact and evidence scores for each critical success factor are rolled up into an overall risk exposure, which again is represented as a simple red-orange-yellow-light green-green indicator (for Excel 2003 users, risk exposure is 5, 4, 3, 2, 1, respectively). The overall risk exposure is the maximum of the risk exposures determined from the responses to the individual questions that support each critical success factor. The "rationale" column may be used to record the source of evidence for later review. The "reset" button clears the impact and evidence ratings for the entire document.

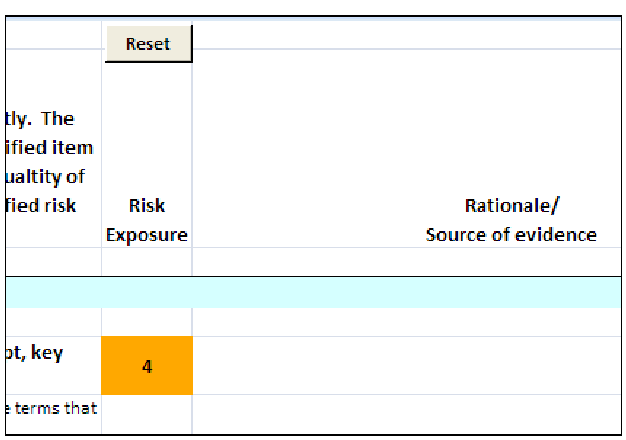


Figure 6. Detail of risk exposure rollup by CSF

Risk exposure (RE) is calculated by multiplying the risk impact by the probability of risk (exposure = impact * p(risk)). Since the impact and probability of risk are represented here as discrete quantities, however, a different approach was used to determine the risk exposure. Figure 7 is an excerpt from the "RE Map" tab of the SEPRT and SECRT tool spreadsheets. On this tab, each combination of impact and p(risk)—where zero represents little-no impact/little-no risk, and three represents critical impact/high risk, as shown by the "Scale"—may be assigned a value from one (green) to five (red) by filling in the "Color" column. The risk exposure matrix resulting from these choices is automatically shown on the right, in a format similar to the five-by-five representation commonly used in risk analysis. In this example, the combination of "no impact" (impact=0) and "independently validated evidence" (p(Risk)=3) result in a medium-low (light-green=2) risk exposure. The values in the "Color" column may be altered to suit the needs of the program being evaluated.

Impact	p(Risk)	Index	Color
0	0	0	1
0	1	1	1
0	2	2	1
0	3	3	2
1	0	4	1
1	1	5	2
1	2	6	3
1	3	7	4
2	0	8	1
2	1	9	3
2	2	10	4
2	3	11	5
3	0	12	2
3	1	13	4
3	2	14	5
3	3	15	5

Impact					
3	2	4	5	5	
2	1	3	4	5	
1	1	2	3	4	
0	1	1	1	2	
	0	1	2	3	p(Risk)

Scale
1
2
3
4
5

Figure 7. Detail of risk exposure mapping

4.2 Tool Tailoring and Extension

Being developed in Excel, the prototype tools are relatively simple to tailor and extend, to explore additional framework concepts. Questions can be added to a CSF by copying and pasting an existing question and modifying it. The formulas for computing risk exposure are straightforward, and can be similarly copied and adjusted to refer to the new questions.

The risk exposure mapping itself is designed to be configurable by the individual project. Using the "RE Mapping" tab, as described in Figure 7 above, combinations of risk impact and probability can be mapped to different risk exposure ratings, simply by modifying the RE numbers in the "Color" column.

Based on feedback from the pilot evaluations, it may be desirable in the future to modify the EM frameworks to be less specific to DoD terminology and milestones. Although the exact phrasing of goals, CSFs, and questions is a topic for further research, the tools are easily modifiable to reflect the desired changes.

There is some interest in adapting the frameworks to address the specific needs of particular application domains. For example, the SE needs for engineering secure systems are more specific than the general SE needs expressed in the present framework. Similarly, organizations focused on ground, sea, air, and space missions would benefit from domain-specific extensions. Future research intends to explore how the framework might be adapted to such specific needs, and to adapt the prototype tools to enable piloting of these future efforts.

5. Summary of Framework and Tool Evaluations

The researchers solicited pilot evaluations of the EM performance and competency frameworks, using the prototype SEPRT and SECRT tools, from industry, government agencies, and academic participants. Because the task re-scoping permitted only a single round of piloting, these initial evaluations were conducted against historical projects and case studies. In addition, the University of Maryland (UMD) Fraunhofer Center (FC) began preliminary evaluations against the Systemic Analysis Database (SADB), compiled by OUSD (AT&L). This evaluation approach allowed analysis of the effectiveness of the frameworks with respect to historical success and failures of the subject projects.

The tools were successfully piloted against five DoD projects, one NASA project, and one commercial project. They were also analyzed by two industrially-experienced colleagues against detailed case studies of a number of DoD and commercial projects. The application domains piloted included space, medical systems, logistics, and systems-of-systems. Results of the pilot evaluations were reported through a web-based survey tool and detailed follow-up interviews, while the case study evaluations were reported through detailed comments from the reviewers.

Evaluations were generally positive, and the frameworks were found to be useful across all project phases except Production, and against all systems types except “legacy development.” The consensus of reviewers was that the frameworks would be most useful in the System Development & Demonstration (SDD) phase, and generally more useful in early phases than later. It was noted, however, that in systems developed using evolutionary strategies, such “early” phases recur throughout the development cycle, extending the usefulness of the frameworks. The evaluations were reported to take 2-5 hours to complete for persons familiar with the projects, with materials that were readily at hand.

Some concerns reported, particularly by the NASA reviewers, were that the frameworks were too DoD-centric in their terminology, milestones, and acquisition frameworks. These reviewers were sufficiently familiar with DoD processes to allow analysis of the NASA projects, but suggested that the CSFs and questions be modified to be more general. In reviewing case study material, some evaluators reported that the EM framework was not specific to any particular problem domain. Finally, several evaluators reported that the frameworks generated too many high-risk findings, which might make the results too overwhelming to take action.

These concerns were partially mitigated with suggestions from the evaluators. Although the general nature of the EM frameworks was intentional in this portion of the research, it suggests that tailoring might be useful to uncover domain-specific shortcomings in SE functions. Two approaches might be used with respect to the DoD-specific nature of the frameworks: the frameworks might be edited to use more generic terms, or new versions tailored to other agencies and domains. With respect to the frameworks uncovering too many high-risk findings, the impact scales have been adjusted to make the adjectives better correspond to the quantitative impacts (Critical—Significant—Moderate—Little-or-No vs. High-Medium-Low-No impact), and a longer risk exposure scale developed to allow more nuanced results.

Details regarding use of the SEPRT (performance) tool are as follows. It was found to be particularly useful in SDD, somewhat useful in early phases, and less useful in later phases. This result is somewhat expected, given the "early-phase" emphasis of the materials used as sources for the frameworks, and suggests that further research might examine the SE strategies that are important in later life-cycle phases, such as testing and configuration management. The evaluators also report that the SEPRT effectiveness ranges from very effective to somewhat effective, with the majority reporting it as effective. Only analysis of one DoD legacy system project reported the tool as ineffective, which suggests that the issues facing such projects may need to be examined more closely. Even with respect to DoD systems, some evaluators reported issues with the terminology used, which might be cleared up with careful editing.

With respect to the SECRT (competency), the evaluators also found the tool most useful in earlier life-cycle phases, rather than later. The usefulness was rated between effective and somewhat effective. Although the SECRT is less well developed than the SEPRT, one reviewer noted that the shortfalls noted by the SECRT might well be used to help justify and explain the need for stronger SE capabilities to program management and acquirers. Another reviewer observed that the choice of person performing the competency evaluation was critical, as it is difficult for a non-technical evaluator to judge competency. Finally, one comment that is more a judgment of state of practice is that, "to be effective, program management must have some control over who is assigned."

Several reviewers comment that the simple red, yellow, green, and blue/gray choices for impact and evidence ratings might be too granular. However, the initial rating scales used a 1-5 range, which workshop participants judged as too complex. The resulting granularity of risk exposure (RE) results might be mitigated using several techniques. The RE calculation has been broadened to allow medium-high (orange) and medium-low (light green) results, which reduces the clumping of all results into medium (yellow) and high (red). The impact scale has also been clarified to make the lowest choice "little or no" impact, rather than "no" impact. Since the prototype tools presently use the maximum RE of all questions in a CSF, another suggestion was to provide a count of the number of REs at this maximum level, as a "red (4)" is clearly worse than a "red (1)." All but the last of these suggestions have already been retrofitted into the SEPRT and SECRT tools, although the changes have not yet been re-piloted.

The evaluations indicate that the concept of "evidence-based" information is not well understood, and may require further explanation and example. For example, one reviewer asks specifically what constitutes "sufficient" evidence. One answer is evidence that an independent, expert reviewer would find sufficient as a compelling and objectively verifiable argument of feasibility. This is a slight modification of the original definition, where the word "external" was used rather than "independent," as one reviewer observed that for some domains, external reviewers would not have sufficient context to perform knowledgeable assessments. It might also be necessary to supplement the framework question set with material that describes the intended goal for each question, so that evidence can be judged against this goal.

In summary, the framework and prototype tools have been shown to be largely efficacious for pilot projects done by familiar experts in a relatively short time, in identifying characteristics of SE efforts that, inadequately performed, will likely lead to difficulties with the program. It remains to demonstrate how well the framework and tools will perform on in-process MDAPs with multiple missions, performers, and independent expert assessors.

C. DoD MDAP SE EM Concepts of Operation

The SEPRT and SECRT framework and tools provide a way for MDAPs (and other projects) to identify the major sources of program risk due to SE shortfalls. This section provides concepts of operation for applying the tools at major milestones, and at other points where other SE EMs such as the INCOSE Leading Indicators have identified likely problem situations and need further understanding of the problem sources and their relative degrees of risk.

Section C.1 establishes the primary criteria for satisfactory program evidence, and provides a vehicle for capturing the evidence called a Feasibility Evidence Description. Section C.2 provides representative MDAP operational scenarios that show how the determination of SEPRT and SECRT impact priorities can be done collaboratively by a program's sponsors and performers at various life cycle points, enabling a cooperative rather than an adversarial approach to system definition and development. Section C.3 shows how the use of feasibility evidence as a first-class deliverable enables programs to plan and control progress toward successful passage of SEPRT- and SECRT-based reviews. Section C.4 describes a process for conducting such reviews, and summarizes successful experiences in applying such processes.

1. Evidence Criteria and Review Milestone Usage

Having shown in Section A.3 that the regions of high payoff for evidence-based specifications, plans, assessments, and reviews are extensive and enterprise-critical, it is now important to define the criteria for the evidence that will be associated with the system development specifications and plans, and reviewed via the SEPRT and SECRT. The criteria are extensions to those for the Anchor Point (AP) milestones defined in [7] and adopted by the Rational Unified Process (RUP) [18],[25]. The extensions have been incorporated into the recently developed Incremental Commitment Model (ICM); details of this model can be found in [10],[23]. Also, comparable benefits can be obtained by adding such criteria, processes, and incentive structures to traditional acquisition methods and reviews.

The evidence criteria are embodied in a Feasibility Evidence Description (FED). It includes *evidence* provided by the developer and validated by independent experts that, *if the system is built to the specified architecture it will:*

1. Satisfy the specified operational concept and requirements, including capability, interfaces, level of service, and evolution
2. Be buildable within the budgets and schedules in the plan
3. Generate a viable return on investment
4. Generate satisfactory outcomes for all of the success-critical stakeholders
5. Identify shortfalls in evidence as risks, and cover them with risk mitigation plans

An FED does not assess a single sequentially developed system definition element, but the consistency, compatibility, and feasibility of several concurrently engineered elements. To make this concurrency work, a set of Anchor Point milestone reviews are performed to ensure that the many concurrent activities are synchronized, stabilized, and risk-assessed at the end of each phase. Each of these reviews is focused on developer-produced and expert-validated *evidence*, documented in the FED (or by pointers to the results of feasibility analyses), to help the system's success-critical stakeholders determine whether to proceed into the next level of commitment. Hence, they are called Commitment Reviews.

The FED is based on evidence from simulations, models, or experiments with planned technologies and increasingly detailed analysis of development approaches and project productivity rates. The parameters used in the analyses should be based on measured component performance or on historical data showing relevant past performance, cost estimation accuracy, and actual developer productivity rates.

As determined by independent experts using the SEPRT and SECRT questions, a shortfall in feasibility evidence indicates a level of program execution uncertainty and a source of program risk. It is often not possible to fully resolve all risks at a given point in the development cycle, but known, unresolved risks need to be identified and covered by risk management plans, including the necessary staffing and funding to address them. The nature of the evidence shortfalls, the strength and affordability of the risk management plans, and the stakeholders' degrees of risk acceptance or avoidance will determine their willingness to commit the necessary resources to proceed. A program with risks is not necessarily bad, particularly if it has strong risk management plans. A program with no risks may be high on achievability, but low on ability to produce a timely payoff or a competitive advantage.

An FED needs to be more than just traceability matrices and PowerPoint charts. Evidence can include results of:

- Prototypes: of networks, robots, user interfaces, COTS interoperability
- Benchmarks: for performance, scalability, accuracy
- Exercises: for mission performance, interoperability, security
- Models: for cost, schedule, performance, reliability; tradeoffs
- Simulations: for mission scalability, performance, reliability
- Early working versions: of infrastructure, data fusion, legacy compatibility
- Previous experience
- Combinations of the above

Not only does the evidence need to be produced, but it needs to be validated by independent experts. These experts need to determine the realism of assumptions, the representativeness of scenarios, the thoroughness of analysis, and the coverage of key off-nominal conditions. At least one DoD MDAP has explicitly included a FED Data Item Description in its list of deliverables.

2. Use of the SERC SE EM Capabilities in Evidence-Based SE

This section shows how the EMs can be used to reach sponsor-performer consensus on the relative impact of each EM upon the project outcome, and of the resources required to achieve it. These then serve as a consensus-based set of criteria that will be used to measure evidence of the project's SE effectiveness, which is then reinforced by becoming a significant determinant of the performer's award fee. Shortfalls in evidence are uncertainties or probabilities of loss, which when multiplied by the relative impact or size of loss, become measures of project risk. These then require risk management plans, employing the major risk mitigation options of buying information, risk avoidance, risk transfer, risk reduction, or risk acceptance. Three early-SE scenarios are provided:

1. At Milestone A: Milestone Decision Authority (MDA) Review of Acquirer Plans

2. Contract Negotiation: MDAP Acquirer and Developer

3. Project Execution: MDAP Developer Manager and Performers.

2.1 Scenario 1: MDA Review of Acquirer Plans at Milestone A

Step 1. The Acquirer submits a proposed acquisition plan to the MDA, along with the SEPRT and SECRT evidence ratings and risk mitigation approaches.

Step 2. The MDA has independent experts review the SEPRT and SECRT ratings. A major finding is that no Analysis of Alternatives has been performed. Only one alternative has been analyzed, but the relative risk shown in SEPRT is low because the Acquirer has assigned it a Little or No Impact rating.

Step 3, Case 1. The Acquirer agrees that the capability needed is critical, but that it is needed quickly for a relatively unique and short-term threat, and that evidence is available that a solution involving Alternative A will be sufficient. The MDA concurs, and gives approval to rapidly proceed with Alternative A.

Step 3, Case 2. The Acquirer states that a Defense Advanced Research Projects Agency (DARPA) demo of the Alternative X technology has shown proof of principle of its feasibility, and that all that is needed is to implement Alternative X for the general case. The independent experts conclude that the proof of principle demo provided no evidence of the solution's scalability or ability to work in degraded battle conditions. The MDA does not give an approval to proceed with Alternative X, but directs the Acquirer to resubmit using a Competitive Prototyping acquisition approach.

In each case, the MDA and Acquirer agree on an acceptable approach. In Case 1, the outcome is a timely and acceptable solution. In Case 2, Competitive Prototyping is used as a way of buying information to reduce risk. At the end of the first round of prototyping, no competitor may be able to develop a scalable and robust solution, and the acquisition can be deferred until the technology is more mature. Or it may be that one or more competitors have produced scalable and robust solutions, and another round of prototyping will determine the best approach and supplier.

2.2 Scenario 2: Acquirer and Winning-Prototype Developer Contract Negotiation

Step 1. The Acquirer specifies SEPRT Critical Success Factor 1.2(d), "Have the claimed quality of service guarantees been validated?" to have Critical impact, and thus to be a major determinant of the Performer's award fee at each review milestone.

Step 2. The Developer is the winning competitive prototyping developer, and clearly the performer of choice. Their response is, "We agree that quality of service evidence is critical, as is addressing it before committing to functional requirements. But we have tied our plans and budgets to the first milestone in your contract, a System Functional Requirements Review that ties our progress payments and award fees to just specifying functionality. If you agree that early QoS evidence is critical, we need to find a way to emphasize this in the contract."

Step 3. The Acquirer responds, "Thanks. That legacy contract clearly undercuts our intent to do evidence-based concurrent engineering, and sets us up for late overruns. We'll redo it and your SE plans and budgets. Next time, we'll address contracting compatibility earlier."

2.3 Scenario 3: Acquirer and Developer Contract Performance

Having agreed on a revised contract and increased early-SE budget and schedule, justified by the rework-avoidance business case in Section A.3, the Acquirer and Developer use Figure 8 as a basis for proceeding. Since the system is not a quick-response development for a relatively unique and short-term threat, the opportunistic development branch is not chosen. The evaluation of SE plans and staffing results in the independent evaluators indicating that the plans and staffing are sound, but also identifying an available mission simulator that can increase the cost-effectiveness of the evidence generation, which the Developer incorporates into the plans.

During development, the project uses the INCOSE Leading Indicators capability to flag any progress indicators that exceed a set of control limits agreed upon by the Acquirer and Developer. At some point, a Leading Indicator shows that progress is behind schedule in modifying the mission simulator. A specialized SEPRT assessment of the simulator subproject finds that difficulties have been encountered in getting the simulator to provide evidence that the system can handle some off-nominal threat scenarios that the simulator was not designed to handle. A quick risk mitigation plan is developed to bring aboard some experts to rework the simulator in time to be used for the off-nominal scenarios.

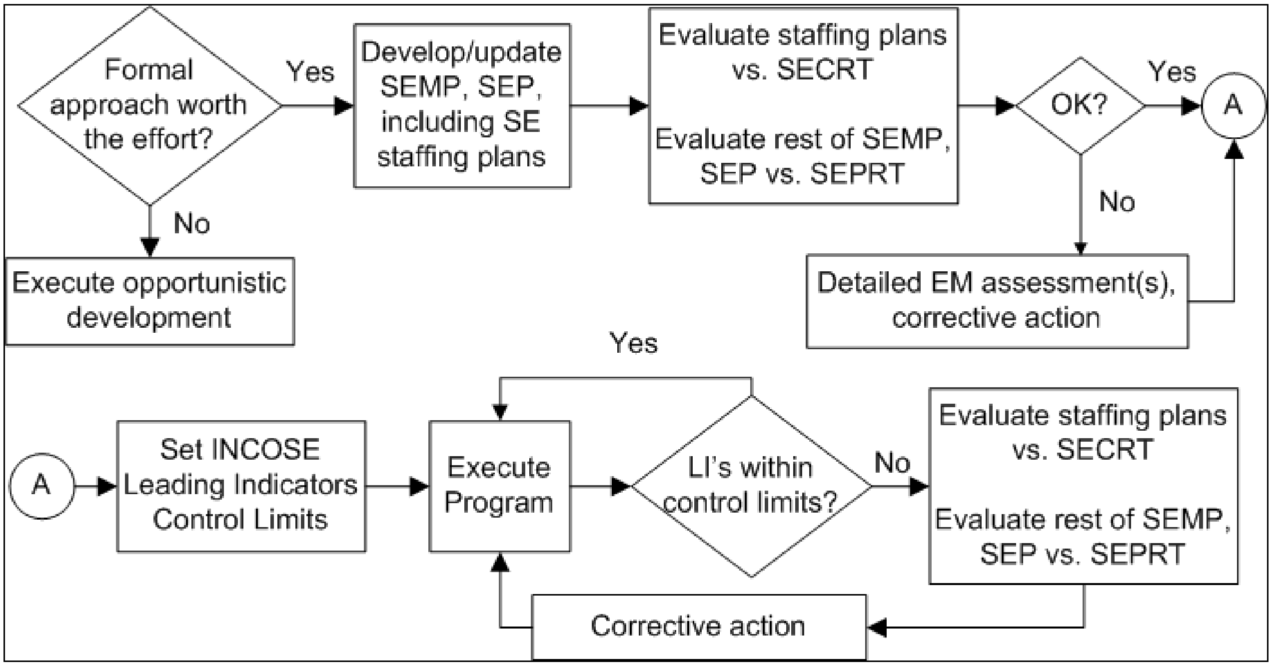


Figure 8. Project SysE EM Operational Concept (for each stage of system definition and development)

3. FED Development Process Framework

The most important characteristic of evidence-based system specifications and plans is that:

- *If the evidence does not accompany the specifications and plans, the specifications and plans are incomplete.*

Thus, event-based reviews, where the event is defined as production of the specifications and plans, need to be replaced by *evidence-based reviews*.

This does not mean that the project needs to spend large amounts of effort in documenting evidence of the feasibility of a simple system. The appropriate level of detail for the contents of the FED is based on the perceived risks and criticality of the system to be developed. It is NOT a "one size fits all" process, but rather a framework to help developers and stakeholders determine the appropriate level of analysis and evaluation. As with reused specifications and plans, evidence can be appropriately reused. If a more complex system than the one being reviewed has been successfully developed by the same team, a pointer to the previous project's evidence and results will be sufficient.

Table 10 outlines a process that can be used for developing feasibility evidence. The process clearly depends on having the appropriate work products for the phase (Step A). As part of the engineering work, high-priority feasibility assurance issues are identified that are critical to the success of the system development program (Step B). These are the issues for which options are explored, and potentially viable options further investigated (Step C). Clearly, these and the later steps are not performed sequentially, but concurrently.

Table 10. Steps for Developing a FED

Step	Description	Examples/Detail
A	Develop phase work-products/artifacts	For a Development Commitment Review (DCR), this would include the system's operational concept, prototypes, requirements, architecture, life cycle plans, and associated assumptions
B	Determine most critical feasibility assurance issues	Issues for which lack of feasibility evidence is program-critical
C	Evaluate feasibility assessment options	Cost-effectiveness; necessary tool, data, scenario availability
D	Select options, develop feasibility assessment plans	The list of options at the end of Section C.1 (prototypes, benchmarks, exercises, etc) is a good starting point
E	Prepare FED assessment plans and earned value milestones	The plans include the enablers in Step G
F	Begin monitoring progress with respect to plans	Also monitor changes to the project, technology, and objectives, and adapt plans
G	Prepare evidence-generation enablers	Assessment criteria Parametric models, parameter values, bases of estimate COTS assessment criteria and plans Benchmarking candidates, test cases Prototypes/simulations, evaluation plans, subjects, and scenarios Instrumentation, data analysis capabilities
H	Perform pilot assessments; evaluate and iterate plans and enablers	Short bottom-line summaries and pointers to evidence files are generally sufficient
I	Assess readiness for Commitment Review	Shortfalls identified as risks and covered by risk mitigation plans Proceed to Commitment Review if ready
J	Hold Commitment Review when ready; adjust plans based on review outcomes	See Commitment Review process overview below.
NOTE: "Steps" are denoted by letters rather than numbers to indicate that many are done concurrently.		

Since the preliminary design and plans are incomplete without the FED, it becomes a first-class project deliverable. This implies that it needs a plan for its development, and that each task in the plan needs to be assigned an appropriate earned value. If possible, the earned value should be based on the potential risk exposure costs, not the perceived available budget.

Besides monitoring progress on developing the system, the project needs to monitor progress on developing the feasibility evidence. This implies applying corrective action if progress falls behind the plans, and adapting the feasibility evidence development plans to changes in the project objectives and plans. If evidence generation is going to be complex, it is generally a good idea to perform pilot assessments. The preparations for the commitment review are discussed next.

1. Commitment Review Process Overview

Figure 9 highlights the activities that need to be performed in preparation for the review, the actual review, as well as the post-review activities and follow-up. The entry criteria include ensuring that the feasibility evidence preparation has been successfully tracking its earned value milestones. The inputs include preparing the domain extensions to the core SEPRT and SECRT framework and tools, identifying committed expert reviewers for each of the review questions, and familiarizing them with the SEPRT-SECRT review process.

The review meeting will include not only the developer SEs and the expert reviewers, but also the stakeholder upper-management decision-makers, who will need some context-setting before the developer responses to reviewer issues are discussed. The review exit criteria and tasks include key stakeholder concurrence on the way forward and commitment to support the next phase, as well as action plans and risk mitigation plans for the issues identified.

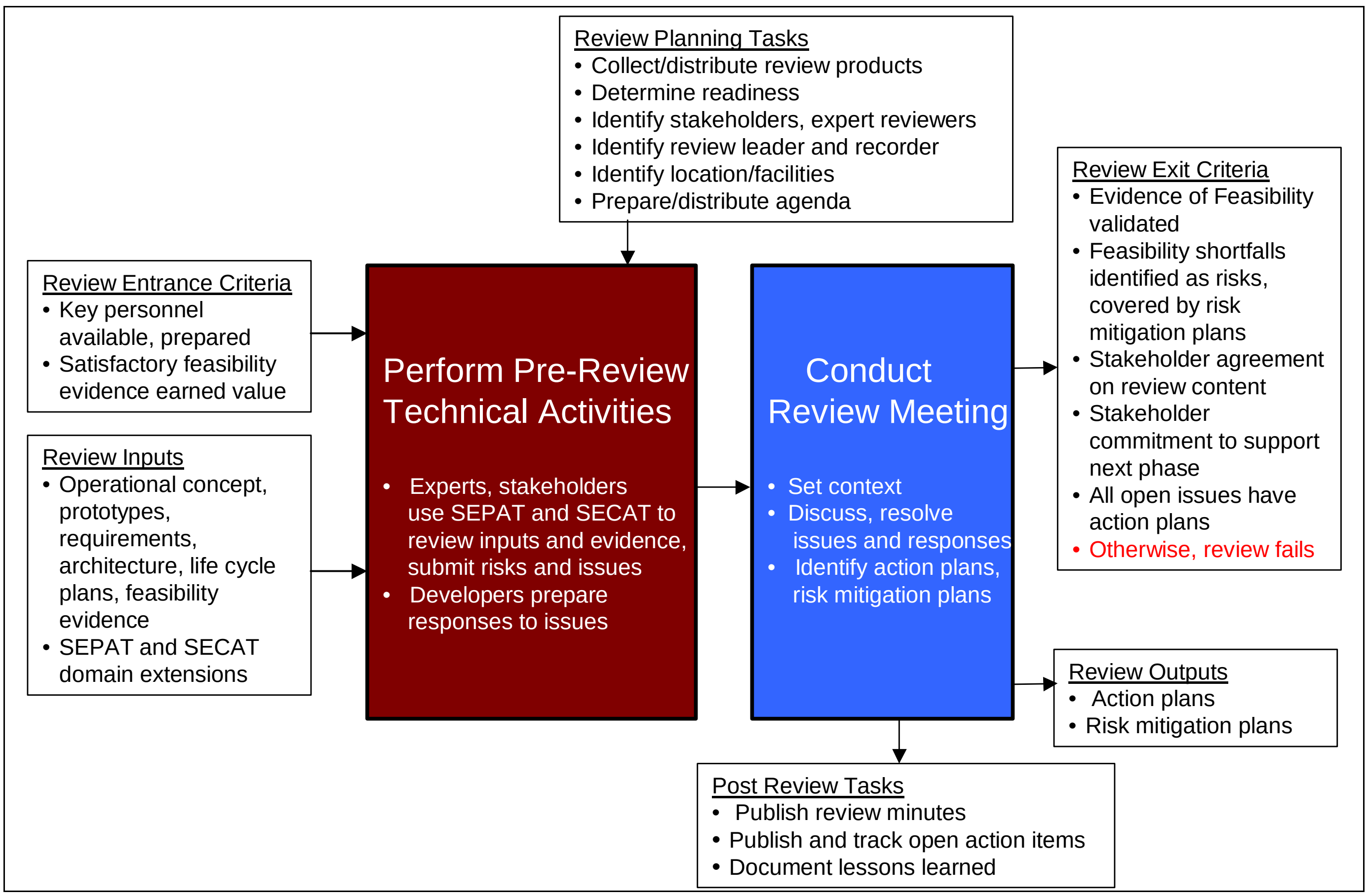


Figure 9. Overview of Commitment Review Process

4.1 Examples of Successful Experiences with Evidence-Based Reviews

AT&T and its spinoffs (Telcordia, Lucent, Avaya, and regional Bell companies) have been successfully using versions of evidence-based reviews since 1988. On average, there has been a 10% savings per reviewed project, with substantially larger savings on a few reviewed projects. More detail on their Architecture Review experience is in [19].

The million-line TRW CCPDS-R project summarized in [25] by Walker Royce, and several similar TRW follow-on projects were further successful examples. Evidence-based anchor point milestone reviews are also an integral part of the Rational Software Process, with many successful implementations [26], although a good many RUP applications have been unable to succeed because of the type of unaddressed contractual constraints discussed in Section 2.2.

The highly successful Abbott Laboratories' next generation intravenous infusion pump documented in chapter 5 of [23] is a good commercial example of evidence-based specifications and plans.

D. Pilot SEPRT and SECRT Evaluation Processes and Lessons Learned

1. Introduction

SEPRT and SECRT were reviewed by NASA's Marshall Space Flight Center (MSFC) to provide an external assessment of the potential application of the tools in a non-DoD development environment and to provide an external review of the tools by product developers working in a similar complex system environment. The review team was comprised a senior systems engineer and senior project manager at MSFC, supported by two researchers from The University of Alabama in Huntsville (UAH). Data from this review was used as inputs to the sponsor workshops and in the development of proposals for extensions to this research effort.

2. Methodology

The review of the SEPRT and SECRT tools was done in four phases. Phase one was a briefing to the assessment team on the research initiatives, a review of the SEPRT and SECRT tools, and a discussion on how the review data would be collected. Phase two was an initial assessment of the tools by a senior systems engineer. Phase three was a detailed assessment of the tools by the entire team. Phase four was the reporting of the assessment results by interview and by completing a web-based survey.

The phase one briefing was a ninety minute session that included both the MSFC and UAH team members. It was held at MSFC. The briefing included an overview of the SERC and a description of the specific research task that the assessment was part of. A review of the data collection methods was included. The MSFC team noted that they would prefer to discuss their review findings before completing the web-based survey, so the research plan was modified to include an interview in phase four. The MSFC team was instructed to contact the UAH team members if any questions on interpretation of the tools came up during the review.

The phase two initial assessment of the tool was done by the MSFC senior systems engineer. The SEPRT and SECRT were provided along with the assessment methodology and supporting documents. The systems engineer did have experience at multiple government agencies, but focused the assessment based on the tools potential use at NASA. Each of the tools was reviewed individually and a written summary of comments and questions was provided.

The phase three detailed assessment was conducted by the senior systems engineer and senior project manager. An additional junior systems engineer was at the meeting but was not significantly involved in the review. The results of the initial review were discussed and specific questions on interpretation of some questions were answered. The MSFC team did contact the UAH team for clarification on some questions. A summary of the findings was then prepared.

The phase four reporting of the results was done by submitting the summary of findings and conducting a telephone interview to discuss findings of the review. The web-based survey was then completed and a copy of the results of the survey was reviewed by the team members.

3. Results

The assessment was done to provide an external assessment of the potential application of the tools in a non-DoD development environment and to provide an external review of the tools by product developers working in a similar complex system environment. The SEPRT and SECRT were found to be generally effective in supporting an aerospace flight hardware program at NASA; however, differences in the models used for project development and terminology differences would need to be addressed before the model would be applicable for general use.

The SEPRT and SECRT were found to be the most useful in concept refinement, system development & demonstration, and operations & support phases. The tools were less useful in the technology development and production & deployment phases. The assessment team noted that the tools could be used at the program, project, and task level. Some technology development activities, such as science experiments, may not find the tools as helpful because of the high degree of process tailoring. The team also noted that there were differences in the way each tool presented questions. It would be easier for the evaluators if the tools were consistent in their formats.

The evidence required to complete SEPRT and SECRT was generally available. It was noted that this could be highly variable and is dependent in part on the experience of the evaluators, the phase the specific program is in, and the contracting mechanisms used. Of specific note was the experience of the evaluators in being able to recognize and locate relevant artifacts to support responses to specific questions in the tools. Accessing artifacts from suppliers could be of concern if the original contracting documents do not call out the need for these.

The NASA team reported approximately five labor hours was required by their team members to complete each of the tools. It was noted that this time would be highly variable, dependent on the experience of the assessment team members and the phase the program is in. Of specific concern was the need to adjust the tool to match the specific uses product developer’s model. Having an external resource, in this case the UAH team, to provide guidance was seen as valuable to the effective use of the tool.

SEPRT and SECRT were reported to be somewhat effective in identifying all performance risks. The assessment team noted that it can be difficult to isolate the performance risk portions of the tool from the general goals and questions, and nearly all the questions could be interpreted as having an effect on performance risk. Understanding the purpose of the tools and how the data will be used by the program management team was noted as important in using the tools effectively.

The team reported that SEPRT and SECRT were assessed to be somewhat effective in helping a program team use an evidence based approach to determining performance risks. This reported result is of note because the tool is currently structured for a DoD product development environment and does not currently have tailoring options to support other non-DoD applications.

4. Lessons Learned

The NASA assessment provided several lessons and opportunities for future extensions to this work. SEPRT and SECRT, in their current form, are targeted for DoD MDAPs. The trade-off is that the more specific the tools are the more effective they can potentially be in managing program performance risks. This increased effectiveness is offset by the lack of a broad application of the tools to other, non-DoD applications. One extension of this research would be to develop a tailoring option for the tools so that individual programs could adjust the scope of the tools to meet their specific program needs. This tailoring could be done based on the requirements called out in the program SEP or SEMP. Another extension would be to develop a specific application set for DoD and a second more generic set for other applications.

The assessment team also noted the tradeoff between having an experienced but heavily tasked senior assessment team complete the tools versus a less experienced but available junior team. Senior managers will want to be familiar with the tools if they are going to implement the results. Completion of the tool would most likely be delegated to the systems engineering team or the logistics team to complete. Having an experienced evaluator use the tools help with accuracy and speed.

To increase the effectiveness of the tool the NASA assessment team noted that linking the SEPRT and SECRT to specific program success criteria would be of significant value. This extension to the research could be approached in two ways. The first would be to link the tools to general program success criteria such as technical requirements, budget and schedule. These would be generic measures common to all programs. The second approach would be to link the tools to specific technical measures such as risk metrics, engineering change notices, test results, and requirements stability. This second approach would be a significant body of work, but would ultimately be more helpful in linking the payback of investing in systems engineering to specific technical performance measures rather than general programmatic results.

E. SADB-DAPS Based SEPRT and SECRT Evaluation Summary

A study was conducted to determine the relationship of SEPRT's system engineering effectiveness measures with the existing Department of Defense's Defense Acquisition Program Support (DAPS) Methodology [22] and its associated Systemic Analysis Database (SADB).

In general, the study found the two frameworks to be complementary. The SEPRT can be characterized of as a subset of the topics covered in the DAPS. Initial analysis of a large set of SADB findings revealed interesting framework comparison details and indicates an opportunity for further research. Supplementary data comparisons and analysis of additional, relevant SADB findings is needed to complete the analysis. Study results indicate that the two frameworks are synergistic and may be leveraged as complements in the evaluation of MDAPS.

1. SEPRT and DAPS/SADB Study Objectives and Approach

The objectives of this study were to:

- Compare SEPRT with DAPS to determine gaps and coverage.
- Establish a baseline for revisions and future comparisons.
- Provide constructive feedback to both model owners as appropriate.
- Determine the significance of SEPRT effectiveness measures as they relate to SADB negative findings.
- Understand whether it is possible to validate the set of SEPRT systems engineering effectiveness measures through an analysis of SADB findings, that is evaluate the ability of the SEPRT to pre-identify MDAP problem areas articulated in the SADB.

Initial research focused on two primary activities: (1) mapping DAPS and SEPRT topical areas and (2) analyzing SEPRT-related findings in the SADB. These activities were performed by very experienced subject matter experts with deep system development and federal acquisition experience; however, the tasks were labor intensive and tedious in nature. Consequently, these initial results are not exhaustive and further validation and verification is required.

The approach used to map the DAPS and SEPRT frameworks included identifying and selecting the key topical areas, searching the text in each framework using key words, documenting these results in a Microsoft Excel spreadsheet, and analyzing and reviewing the resulting comparison map. In parallel, an investigation of the SADB findings was performed to explore the use of the SADB in evaluating the ability of the SEPRT to pre-identify SADB problem areas. This included submitting a request for SADB findings, sorting and analyzing the data set, and comparing the findings with the SEPRT.

2. Existing Defense Acquisition Program Support Tools

The Defense Acquisition Program Support (DAPS) Methodology was developed by the US Department of Defense, Office of the Deputy Under Secretary of Defense for Acquisition and Technology (OUSD (AT&L)), Systems and Software Engineering. The most recent version, 2.0 (Change 3), was published March 20, 2009. The objectives of this methodology are to:

- Improve the OUSD(AT&L) decision-making process for Major Defense Acquisition Programs (MDAS) and Major Automated Information Systems programs through quality systems engineering and program assessment support.
- Facilitate successful execution of a program through the provision of independent, actionable recommendations to the government program management office (PMO).

The *DAPS Methodology* is used in a very specific Department of Defense context. In this context, the methodology

- Provides the tailorable framework for conducting Program Support Reviews (PSRs) to assist program managers and DoD decision makers in preparation for milestone decision reviews.
- Provides a standardized approach (detailed review typology) to conducting PSRs, allowing for the participation of a broad cadre of subject matter experts while expecting the same level of coverage and quality among all reviews.

- Enabled the creation of the Systemic Analysis Database (SADB) of program issues and root causes. This database contains findings from reviews conducted using DAPS and allows systemic analyses that can be used to effect improvements to the acquisition process (e.g., policies, tools, and education) and identify best practices.

The *DAPS Methodology* topical area content focuses on systems engineering, but covers a broader range of subjects in consideration all aspects of acquisition management, including resource planning, management methods and tools, earned value management, logistics, and other areas. The methodology is composed of a robust listing of programmatic and technical areas, sub-areas, and factors. It was developed to be both broad in scope and detailed enough to enable application to programs of all types.

The First-Level Programmatic and Technical Areas are defined as follows:

1. Mission Capabilities
2. Resources
3. Management
4. Technical Process
5. Performance
6. Special Interest Areas

The *DAPS Methodology* provides a complete description of each programmatic and technical area as well as its intended use and processes.

3. SEPRT – DAPS Framework Mapping Results

Raw data results of the mapping between the SEPRT and DAPS frameworks were documented in a Microsoft Excel spreadsheet. Figure 1 provides a sample of this mapping. A complete mapping of the SEPRT and DAPS frameworks can be found in an attachment to this report. As indicated previously, these initial results are not exhaustive and further validation and verification is required. However, it can be determined that the two frameworks overlap extensively and nearly each area in the SEPRT can be traced to the DAPS in some fashion.

SE EM Framework Area		Interpretation	DAPS Section	DAPS Topic Covered	Comments/Observations
1	**Concurrent definition of system requirements and solutions**				
1.1	**Understanding of stakeholder needs: capabilities, operational concept, key performance parameters, enterprise fit (legacy)**		1.1	CONOPS	
1.1.1	At Milestone A, have the KPPs been identified in clear, comprehensive, concise terms that are understandable to the users of the system?	Understandable, comprehensive requirements	1.3.2	KPPs and KSAs	KPPs are required to be "established and documented"; no guidance on understandability/quality of KPP; however states-->
1.1.2	Has a CONOPS been developed showing that the system can be operated to handle both nominal and off-nominal workloads, and to meet response time requirements?	feasible workload demonstrated at CONOPS; are scenarios quantified	1.1 1.2 1.3.1	CONOPS Analysis of Alternatives Reasonableness, Stability, and Testability	DAPS specifies "realistic" scenarios, not necessarily "nominal and off-nominal workloads." These terms and "response time" are more network-oriented. Quantification is given by "measures of effectiveness."
1.1.3	Has the ability of the system to meet mission effectiveness goals been verified through the use of modeling and simulation?	verification of mission goals	1.2.1 1.3.1 4.4.2	Validity and Currency (1.2 Analysis of Alternatives) Reasonableness, Stability, and Testability Modeling and Simulation Tools	

Figure 10. SEPRT – DAPS Mapping Sample

Some summary observations include:

- The SEPRT has ‘rolled up’ many subtopics into fewer effectiveness areas; DAPS is more broad and more specific
  - Specific issues (e.g., complementary programs) are called out more explicitly in DAPS and handled more generically as ‘risks’ in SEPRT.
  - DAPS discusses DoD-specific artifacts and products (e.g., those required for DoDAF, CARD, JCIDS, DIACAP).
- Several key concepts found in SEPRT seem to be absent or used in a different manner in the DAPS context, such as
  - Negotiating roles & responsibilities
  - Nominal/off-nominal
  - Stakeholder concurrence/acceptance
  - Validated
  - Feasibility evidence
  - Timeboxing
- DAPS is very DoD-process oriented; as a result, its guidance on what the program should do when is more specific, e.g., each section addresses Milestones A, B, and C as appropriate.
- DAPS has more information about expected implementation, often providing a discussion of the rationale or importance of the topic.

- DAPS makes several assumptions regarding the programs' required characteristics, processes, such as the required use of Modular Open Systems Approach, DoDAF, and Earned Value Management. These types of assumptions are not generally found in SEPRT.

Detailed differences between the frameworks are described below:

- SEPRT does not address 'ilities' as independent topics as addressed in DAPS:
    - 5.2 Suitability
        - 5.2.1 Reliability Assessment
        - 5.2.2 Availability Assessment
        - 5.2.3 Maintainability Assessment
    - 5.3 Survivability
- SEPRT does not cover domain specifics or specialty engineering areas, such as Security; Information Assurance; Weapons Systems; Spectrum Management; Human Systems Integration; Environment, Safety, Occupational Health; and Corrosion.
- SEPRT does not address topics beyond the development phase, including production, logistics, maintenance upgrades.
- DAPS often mentions an incremental approach, but it does not address how to divide requirements into increments or prioritize requirements; advocates open systems (1.4, 1.4.4, 3.4.4).
- DAPS requires KPPs be established and documented, but there is no guidance on the understandability/quality of KPP (1.1.1).
- DAPS does not explicitly require key stakeholder agreement/acceptance on the system boundary and assumptions of its environment though it does expect that collaboration mechanisms are in place (1.3.4, 2.3.1, 2.3.2, 2.4.1, 3.4.2, 4.5.4).
- DAPS does not address 'negotiation' of roles and responsibilities, but rather assumes the PM identifies what needs to be done and who shall address it (1.1.4).
- DAPS does not specifically address the timeframe of personnel assignments, although strategy and schedule realism is emphasized (1.4.1, 2.1.3, 2.5.3).
- DAPS does address quality of staff in general, but does not specifically address staff needed in critical areas or what constitutes a qualified person (2.1.1, 2.2.2).
- DAPS has an Overarching Integrated Product Team but it is unclear on this group's purpose or participation in the program during all life cycles; a "super IPT" is not mentioned, but DAPS uses planning and reviews to resolve issues (2.2.3).
- DAPS specifies 'realistic' scenarios, but not 'nominal' and 'off-nominal' workloads (1.1.2).

- DAPS is not specific as SEPRT regarding network-oriented performance, e.g., ‘response times’ (1.1.2).
- DAPS considers flexibility relative to system design, but does not focus on the ability of requirements to take on future mission growth over the program lifecycle (1.4.2).
- DAPS seems to recommend Modular Open Systems Approach as an approach to resolve conflicts among strongly coupled objectives (2.3.3).
- DAPS does not address COTS validation, though it does address COTS suitability through an acceptance process (1.2.4).
- DAPS mentions prototypes as part of the SDD process, but does not explicitly mention their use for mitigating risks (1.4.3).
- DAPS addresses competitive prototyping and expects the results to be reviewed at major reviews, but it is unclear how to plan for it from a contracting, PM perspective (2.4.1, 2.4.2).
- DAPS does not address effective strategies for addressing proposed changes, such as triage (4.4.1).
- DAPS relates the expected level of formality with size of the project in terms of cost versus stability of requirements (4.1.1).
- DAPS does not appear to have an explicit requirement for traceability between requirements and architecture (3.2.4).
- DAPS does not address the concept of time-determined development, though it does expect schedule constraints are dealt with and recommends a schedule reserve (3.4.4).
- DAPS discusses milestone reviews at length; however, it is not clear that evidence of feasibility is available and ‘checking the box’ is explicitly avoided (4.5).
- DAPS does not explicitly discuss feasibility evidence, and therefore does not address related progress measures (4.2.4).
- DAPS discusses milestone reviews at length; however, it is not clear that evidence of feasibility is available and ‘checking the box’ is explicitly avoided (4.5).

It should be noted that these differences are not described as positive or negative. It is clear that the *DAPS Methodology* has been carefully crafted to incorporate the constraints and complexities of systems development within the DoD context. Discussions with the *DAPS Methodology* owners are required to determine whether there is opportunity or rationale for incorporating SEPRT key concepts, for example, into the DAPS and conversely, SEPRT use of DAPS elaborations.

4. SADB Analysis Results

A request for SADB findings was requested in accordance with the SADB Report Request Form. The data requested was intended to be related to SEPRT Area 1: *Concurrent Definition of System Requirements and Solutions*. The following DAPS Sections were indicated on the request form:

1 Mission Capabilities (1.1 CONOPS, 1.2 Analysis of Alternatives, 1.3 Capabilities)

2.2 Budget Sufficiency and Phasing

3.1 Acquisition Strategy

3.2 Knowledge-Based Decisions and Milestones

4.5.2 Verification Correlation

4.6 Design Verification

4.7 Supportability Planning

This data request represents 9 of 59 DAPS factors for comparison. In addition to the checked areas, the request included the following additional key words: Increments; Understandable, comprehensive, concise requirements; Verification of mission goals; Stakeholder roles; Legacy, context, operational concept verification; Exploration of alternative solutions; External interfaces; Third-party solutions; Prioritization of requirements; System development.

A total of 1,412 findings were received in response to this request. Of these findings, 704 were classified as Negative Findings, 491 were Neutral Findings, and 217 were Positive Findings. Figure 11 illustrates the characterization of the data set.

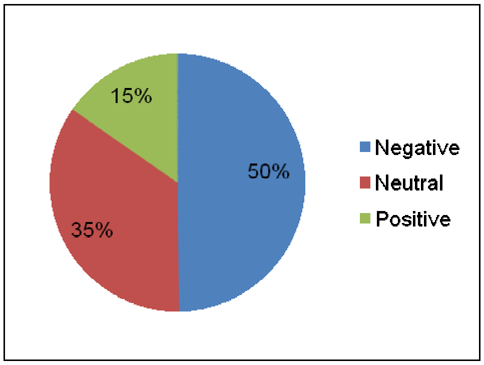


Figure 11. Data Set

Additional data characterization observations regarding the data received include:

- The findings received represent programs sponsored by the Army, Navy, Air Force, Marine Corps, as well as other DoD components.
- The largest group of findings is related to DAPS section 1.3.1: Reasonableness, Stability, Testability.
- Of ALL findings received, nearly half or more are related to each DAPS section are Negative Findings, except those related to the following areas:
  - Mission Description
  - 1.2.1 Validity and Concurrency

- 1.2.2 Linkage and Traceability
- 4.7.2 Performance-Based Logistics

- About 74% of the NEGATIVE findings
    - Have 50 or more findings related to its DAPS section
    - Cover the following seven (7) DAPS areas:
        - 1.3.1 Reasonableness, Stability, Testability
        - 2.2.1 Program Funding and Allocation
        - Credibility
        - Acceptability
        - 4.6.1 Test and Evaluation Plan
        - 4.6.2 Verification Correlation
        - 4.7.3 Sustainment

5. Recommendations and Conclusions

The initial results of the study indicate that the DAPS and SEPRT frameworks are complementary. There is a great deal of overlap between the frameworks and there are opportunities to leverage details in each framework. The large number of relevant SADB findings (over 1,400) indicates synergy between the frameworks. Specific considerations for improvements to SEPRT include:

- Clarify the program life cycle assumed by the SEPRT framework, for example, milestone events and timeline.
- Include definitions with the SEPRT for terms not currently used, e.g., mission effectiveness; concurrent solution; feasibility evidence; quality of service; program governance process; level of project requirements emergence; earned value *target.*
- More specific guidance is needed regarding what is meant by ‘*validated*’ requirements, quality of service guarantees, and solutions, and ‘*clearly demonstrated compliance*’ with legal, policy, regulatory, standards, security, etc.
- Clarify how to interpret the SEPRT given a specific perspective, e.g., government PMO staffer versus system development contractor.
- Provide discussion on key concepts, especially those that are under-addressed by DAPS.
- Include guidance or references to assist in understanding and implementation of the SEPRT.

- Differentiate the issues cited in 2.4.3: resources, process infrastructure, organizational viability, project alignment with business unit.

- Separate 2.5.2 issues related to empowerment and qualified persons.

- Reword 3.2.1 to be more system oriented versus software.

- Clarify meaning of 3.2.5: "Does the architecture adequately reconcile functional hardware 'part-of' hierarchies with layered software 'served-by' hierarchies?"

- Change earned value *targets* to earned value *thresholds in* 4.2.4.

As mentioned earlier, it is recommended that discussions with *DAPS Methodology* owners be conducted to provide the details of this study to determine if there are any salient improvements that may be made to the DAPS.

Additionally, it is recommended that further analysis of SADB findings be conducted to leverage the existing data and refine the set of SEPRT effectiveness measures.

F. Conclusions and Recommendations

1. Conclusions

DoD programs need effective systems engineering (SE) to succeed.

DoD program managers need early warning of any risks to achieving effective SE.

This SERC project has synthesized the best analyses of DoD SE effectiveness risk sources into a lean framework and toolset for early identification of SE-related program risks.

Three important points need to be made about these risks.

- They are generally not indicators of "bad SE." Although SE can be done badly, more often the risks are consequences of inadequate program funding (SE is the first victim of an underbudgeted program), of misguided contract provisions (when a program manager is faced with the choice between allocating limited SE resources toward producing contract-incentivized functional specifications vs. addressing key performance parameter risks, the path of least resistance is to obey the contract), or of management temptations to show early progress on the easy parts while deferring the hard parts till later.

- Analyses have shown that unaddressed risk generally leads to serious budget and schedule overruns.

- Risks are not necessarily bad. If an early capability is needed, and the risky solution has been shown to be superior to the alternatives, accepting and focusing on mitigating the risk is generally better than waiting for a better alternative to show up.

The results of the SEPRT and SECRT pilot assessments, the DAPS and SADB comparative analysis, and the quantitative business case analysis for the use of the SE EM framework, tools, and operational concepts is sufficiently positive to conclude that implementation of the approach is worth pursuing. Presentations at recent workshops have generated considerable interest in refining, using, and extending the capabilities and in co-funding the followon research. However, the framework and prototype tools have been shown to be largely efficacious only to date for pilot projects done by familiar experts in a relatively short time. It remains to demonstrate how well the framework and tools will perform on in-process MDAPs with multiple missions, performers, and independent expert assessors.

The parametric analysis in Section A.3 concludes that the greater the project's size, criticality, and stability are, the greater is the need for validated architecture feasibility evidence (i.e., evidence-based specifications and plans). However, for very small, low-criticality projects with high volatility, the evidence generation efforts would make little difference and would need to be continuously redone, producing a negative return on investment. In such cases, agile methods such as rapid prototyping, Scrum and eXtreme Programming will be more effective. Overall, evidence-based specifications and plans will not guarantee a successful project, but in general will eliminate many of the software delivery overruns and shortfalls experienced on current software projects.

Some implications of defining feasibility evidence as a "first class" project deliverable are that it needs to be planned (with resources), and made part of the project's earned value management system. Any shortfalls in evidence are sources of uncertainty and risk, and should be covered by risk management plans. The main contributions of the SERC SE EM project have been to provide experience-based approaches and operational concepts for the use of evidence criteria, evidence-generation procedures, and SE effectiveness measures for monitoring evidence generation, which support the ability to perform evidence-based SE on DoD MDAPs. And finally, evidence-based specifications and plans such as those provided by the SERC SE EM capabilities and the Feasibility Evidence Description can and should be added to traditional milestone reviews.

As a bottom line, the SERC SE capabilities have strong potential for transforming the largely unmeasured DoD SE activity content on current MDAPs and other projects into an evidence-based measurement and management approach for both improving the outcomes of current projects, and for developing a knowledge base that can serve as a basis for continuing DoD SE effectiveness improvement.

2. Recommendations

Based on the Conclusions, we recommend a two-step approach for achieving a SE EM initial operational capability and transitioning it to a sustaining organization. Phase IIa is proposed to begin with research on three tasks. The first task would involve experimentation with domain extensions and larger-scale pilots. The second task would involve performing and analyzing the results of further completed successful and unsuccessful projects to test the hypothesis that there is a critical small set of critical success-failure factors that could serve as top-level early warning indicators. The third task would involve extended analyses of the commonalities and variabilities between the SERC SE EM apabilities and the DAPS methodology and SADB results. This could strengthen both and enable them to be used in complementary ways.

Phase IIb would continue with incremental elaboration, experimentation, and refinement of the preferred approaches, and coordination with complementary efforts. Candidate tasks would include EM tool top-risk summaries, suggestions for mitigating the identified risks, ease of creating domain-specific extensions, creating further users-guide and tutorial material, creating and populating a knowledge base of the results, plans for transitioning the support and evolution of the tools to an appropriate support organization such as DAU, and continuing to coordinate the tools' content with complementary initiatives such as the INCOSE Leading Indicators upgrade, the NDIA enterprise-oriented personnel competency initiative, and the SERC SE Body of Knowledge and Reference Curriculum RT.

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H. List of Acronyms

AoA – Analysis of Alternatives

AP – Anchor Point

CCPDS-R – Command Center Processing and Display System-Replacement

CMU/SEI – Carnegie-Mellon University / Software Engineering Institute

COCOMO – Constructive Cost Model

COSYSMO – Constructive Systems Engineering Cost Model

COTS – Commercial Off-the-Shelf

CSSE – Center for Systems and Software Engineering

CSF – Critical Success Factor

DAPS – Defense Acquisition Program Support

DARPA – Defense Advanced Research Projects Agency

DAU – Defense Acquisition University

DCR – Development Commitment Review

DID – Data Item Description

DoD – Department of Defense

EM – Effectiveness Measurement

FED – Feasibility Evidence Description

GAO – General Accountability Office

GFI – Government Furnished Information

GQM – Goal, Question, Metric

IBM – International Business Machines Corporation

IC – Intelligence Community

ICM – Incremental Commitment Model

INCOSE – International Council on Systems Engineering\

IPT – Integrated Product Team

KPP – Key Performance Parameters

KSA – Knowledge, Skills, and Abilities

KSLOC – Thousand Source Lines of Code

LI – Leading Indicator

MDA – Milestone Decision Authority

MDAP – Major Defense Acquisition Program

MIT – Massachusetts Institute of Technology

MPT – Methods, Processes, and Tools

NDI – Non-Development Item

NDIA – National Defense Industrial Association

NRC – National Research Council

NUWC – Naval Undersea Warfare Center

OUSD(AT&L) – Office of the Under Secretary of Defense (Acquisition, Technology, and Logistics)

PEO-PM – Program Executive Officer - Program Manager

PDR – Preliminary Design Review

PoPS – Probability of Program Success

PSTL – Program Support Team Leader

RDT&E – Research, Development, Testing & Evaluation

RAA – Responsibility, Authority, and Accountability

RESL – COCOMO II Architecture and Risk Resolution Factor

ROI – Return on Investment

RUP – Rational Unified Process

SADB – Systemic Analysis Database

SE – Systems Engineering

SECRT – Systems Engineering Competency Risk Tool

SEI-CMMI – Software Engineering Institute Capability Maturity Model Integration

SEPRT – Systems Engineering Performance Risk Tool

SERC – Systems Engineering Research Center

SISAIG – Software Intensive Systems Acquisition Improvement Group

UAH – University of Alabama in Huntsville

UARC – University Affiliated Research Center

UML – Unified Modeling Language

USC – University of Southern California

APPENDIX A: GOALS, CRITICAL SUCCESS FACTORS, AND QUESTIONS

This section has the Goals, Critical Success Factors, and Questions for both the SEPRT and the SECRT.

SEPRT – Goals, Critical Success Factors, and Questions

Goal 1. Concurrent definition of system requirements and solutions

CSF 1.1 Understanding of stakeholder needs: capabilities, operational concept, key performance parameters, enterprise fit (legacy)

(a) At Milestone A, have the Key Performance Parameters (KPPs) been identified in clear, comprehensive, concise terms that are understandable to the users of the system?

(b) Has a Concept of Operations (CONOPS) been developed showing that the system can be operated to handle both nominal and off-nominal workloads and meet response time requirements?

(c) Has the ability of the system to meet mission effectiveness goals been verified through the use of modeling and simulation?

(d) Have the success-critical stakeholders been identified and their roles and responsibilities negotiated?

(e) Have questions about the fit of the system into the stakeholders' context—acquirers, end users, administrators, interoperators, maintainers, etc.—been adequately explored?

CSF 1.2 Concurrent exploration of solution opportunities; Analysis of Alternatives (AoAs) for cost-effectiveness and risk (measures of effectiveness)

(a) Have at least two alternative approaches been explored and evaluated?

(b) At Milestone B, has the government structured the program plan to ensure that the contractor addresses the allocation of capabilities to hardware, software, and human elements sufficiently early in the development program?

(c) Has the claimed degree of reuse been validated?

(d) Have the claimed quality of service guarantees been validated?

(e) Have proposed Commercial Off-the-Shelf (COTS) and third-party solutions been validated for maturity, compatibility, supportability, suitability, and effectiveness, throughout the expected system lifetime?

CSF 1.3 System scoping & requirements definition (external interfaces; Memoranda of Agreement (MoA))

(a) Have external interface complexities been identified and addressed via MoAs or their equivalent? Is there a plan to mitigate their risks?

(b) At Milestone B, are the major system-level requirements (including all KPPs) defined sufficiently to provide a stable basis for the development through Initial Operational Capability (IOC)?

(c) By Milestone A, is there a plan to have information exchange protocols established for the whole system and its segments by Milestone B?

(d) Have the key stakeholders agreed on the system boundary and assumptions about its environment?

CSF 1.4 Prioritization of requirements & allocation to increments

(a) Can an initial capability be achieved within the time that the key program leaders are expected to remain engaged in their current jobs (normally less than 5 years or so after Milestone B)? If this is not possible for a complex major development program, can critical subsystems, or at least a key subset of them, be demonstrated within that time frame?

(b) At Milestone B, do the requirements and proposed solutions take into account likely future mission growth over the program life cycle?

(c) Have appropriate early evaluation phases, such as competitive prototyping, been considered or executed for high-risk/low-maturity components of the system?

(d) Have stakeholders agreed on prioritization of system features and their allocation to development increments?

Goal 2. System life-cycle organization, planning, and staffing

CSF 2.1 Establishment of stakeholder life-cycle Responsibilities, Authorities, and Accountabilities (RAAs) (for system definition & system development)

(a) Are the stakeholders who have been identified as critical to the success of the project represented by highly qualified personnel -- those who are collaborative, representative, empowered, committed, and knowledgeable?

(b) At Milestone A, are there validated plans, budgets, and schedules defining how the pre-Milestone B activity will be done, and by whom?

(c) Has the government attempted to align the duration of the program manager's assignment with key deliverables and milestones in the program?

(d) Have the key stakeholders agreed to the proposed assignments of system roles, responsibilities, and authorities?

CSF 2.2 Establishment of Integrated Product Team (IPT) RAAs, cross-IPT coordination needs

(a) Does the project make effective use of Integrated Project Teams (IPTs) throughout the supplier hierarchy?

(b) Are the IPTs staffed by highly qualified personnel, as in 2.1 (a)?

(c) For IPTs addressing strongly coupled objectives, are there super-IPTs for resolving conflicts among the objectives?

CSF 2.3 Establishment of necessary plans and resources for meeting objectives

(a) Have decisions about the use of one-shot, incremental, or evolutionary development been validated for appropriateness and feasibility, and accepted by the key stakeholders?

(b) Have system definition, development, test, and evolution plans, budgets, and schedules been validated for appropriateness and feasibility, and accepted by the key stakeholders?

(c) Is there a valid business case for the system, relating the life cycle system benefits to the system total cost of ownership?

CSF 2.4 Establishment of appropriate source selection, contracting, and incentive structures

(a) Has the competitive prototyping option been addressed, and the decision accepted by the key stakeholders?

(b) If doing competitive prototyping, have adequate plans and preparations been made for exercising and evaluating the prototypes, and for sustaining core competitive teams during evaluation and downselecting?

(c) Is the status of the candidate performer's business and team "healthy," both in terms of business indicators, and within the industrial base for the program area? Is the program aligned with the core business of the unit, and staffed adequately and appropriately?

(d) Has the acquiring organization successfully completed projects similar to this one in the past?

(e) Has the candidate performing organization successfully completed projects similar to this one in the past?

(f) Is the program governance process, and in particular the system engineering plan, well articulated and compatible with the goals of the program?

CSF 2.5 Establishment of necessary personnel competencies

(a) Does the government have access over the life of the program to the talent required to manage the program? Does it have a strategy over the life of the program for using the best people available in the government, the Federally Funded Research and Development Centers (FFRDCs), and the professional service industry?

(b) At Milestone B, have sufficiently talented and experienced program and systems engineering managers been identified? Have they been empowered to tailor processes and to enforce development stability from Milestone B through IOC?

(c) Has the government attempted to align the duration of the program manager's assignment with key deliverables and milestones in the program?

(d) Is the quantity of developer systems engineering personnel assigned, their skill and seniority mix, and the time phasing of their application throughout the program lifecycle, appropriate?

Goal 3. Technology Maturing, Architecting

CSF 3.1 COTS/Non-Development Item (NDI)/Services evaluation, selection, validation for maturity & compatibility

(a) Have COTS/NDI/Services opportunities been evaluated prior to baselining requirements?

(b) Have COTS/NDI/Services scalability, compatibility, quality of service, and life cycle support risks been thoroughly addressed?

(c) Has a COTS/NDI/Services life cycle refresh strategy been developed and validated?

CSF 3.2 Life-cycle architecture definition & validation

(a) Has the system been partitioned to define segments that can be independently developed and tested to the greatest degree possible?

(b) By Milestone A, is there a plan to have internal and external information exchange protocols established and validated for the whole system and its segments by Milestone B?

(c) Does the project have adequate processes in place to define the verification, test & validation, and acceptance of systems and system elements at all phases of definition and development?

(d) Is there a clear, consistent, and traceable relationship between system requirements and architectural elements? Have potential off-nominal architecture-breakers been addressed?

(e) Does the architecture adequately reconcile functional hardware part-of hierarchies with layered software served-by hierarchies?

(f) Has a Work Breakdown Structure (WBS) been developed with the active participation of all relevant stakeholders, which accurately reflects both the hardware and the software product structure?

CSF 3.3 Use of prototypes, exercises, models, and simulations to determine technological solution maturity

(a) Will risky new technology mature before Milestone B? Is there a risk mitigation plan?

(b) Have the key non-technical risk drivers been identified and covered by risk mitigation plans?

(c) Is there a sufficient collection of models and appropriate simulation and exercise environments to validate the selected concept and the CONOPS against the KPPs?

(d) Has the claimed degree of reuse been validated?

CSF 3.4 Validated system engineering, development, manufacturing, operations & maintenance budgets and schedules

(a) Are the major known cost and schedule drivers and risks explicitly identified, and is there a plan to track and reduce uncertainty?

(b) Have the cost confidence levels been developed and accepted by the key system stakeholders?

(c) Is there a top-to-bottom plan for how the total system will be integrated and tested? Does it adequately consider integration facilities development and earlier integration testing?

(d) If timeboxing or time-determined development is used to stabilize schedules, have features been prioritized and the system architected for ease of adding or dropping borderline features?

(e) Are there strategies and plans for evolving the architecture while stabilizing development and providing continuity of service?

Goal 4. Evidence-based progress monitoring and commitment reviews

CSF 4.1 Monitoring of system definition, development and test progress vs. plans

(a) Are the levels and formality of plans, metrics, evaluation criteria, and associated mechanisms (IMP, IMS, WBS, EVMS) commensurate with the level of project requirements emergence and stability? (too little is risky for pre-specifiable and stable requirements; too much is risky for emergent and unstable requirements)

(b) Are the project's staffing plans and buildup for progress monitoring adequate with respect to required levels of expertise?

(c) Have most of the planned project personnel billets been filled with staff possessing at least the required qualification level?

(d) Is the project adequately identifying and managing its risks?

(e) Have the processes for conducting reviews been evaluated for feasibility, reasonableness, completeness, and assurance of independence?

(f) Has compliance with legal, policy, regulatory, standards, and security requirements been clearly demonstrated?

CSF 4.2 Monitoring of feasibility evidence development progress vs. plans

(a) Has the project identified the highest risk areas on which to focus feasibility analysis?

(b) Has the project analyzed alternative methods of evaluating feasibility (models, simulations, benchmarks, prototypes, reference checking, past performance, etc.) and prepared the infrastructure for using the most cost-effective choices?

(c) Has the project identified a full set of representative operational scenarios across which to evaluate feasibility?

(d) Has the project prepared milestone plans and earned value targets for measuring progress in developing feasibility evidence?

(e) Is the project successfully monitoring progress and applying corrective action where necessary?

CSF 4.3 Monitoring, assessment, and replanning for changes in needs, opportunities, and resources

(a) Does the project have an effective strategy for performing triage (accept, defer, reject) on proposed changes, that does not destabilize ongoing development?

(b) Does the project have an adequate capability for performing change impact analysis and involving appropriate stakeholders in addressing and prioritizing changes?

(c) Is the project adequately verifying and validating proposed changes for feasibility and cost-effectiveness?

CSF 4.3 Use of milestone reviews to ensure stakeholder commitment to proceed?

(a) Are milestone review dates based on availability of feasibility evidence versus on availability of artifacts or on planned review dates?

(b) Are artifacts and evidence of feasibility evaluated and risky shortfalls identified by key stakeholders and independent experts prior to review events?

(c) Are developer responses to identified risks prepared prior to review events?

(d) Do reviews achieve risk-based concurrence of key stakeholders on whether to proceed into the next phase? (proceed; skip a phase; revisit the current phase; terminate or rescope the project)

SECRT – Goals, Critical Success Factors, and Questions

Goal 1. Concurrent definition of system requirements and solutions

CSF 1.1 Understanding of stakeholder needs: capabilities, operational concept, key performance parameters, enterprise fit (legacy). Ability to analyze strengths and shortfalls in current-system operations via:

(a) Participatory workshops, surveys, focus groups

(b) Operations research techniques: operations data collection and analysis

(c) Mission effectiveness modeling and simulation

(d) Prototypes, scenarios, stories, personas

(e) Ethnographic techniques: Interviews, sampled observations, cognitive task analysis

CSF 1.2 Concurrent exploration of solution opportunities; Analysis of Alternatives for cost-effectiveness & risk (Measures of Effectiveness). Ability to identify and assess alternative solution opportunities via experimentation and analysis of:

(a) Alternative work procedures, non-materiel solutions

(b) Purchased or furnished products and services

(c) Emerging technology

(d) Competitive prototyping

CSF 1.3 System scoping & requirements definition (External interfaces; Memoranda of Agreement). Ability to establish system scope and requirements via:

(a) Cost-schedule-effectiveness assessment of needs vs. opportunities

(b) Organizational responsibilities, authorities, and accountabilities (RAAs) assessment

(c) Appropriate degrees of requirements completeness, consistency, testability, and variability due to emergence considerations

CSF 1.4 Prioritization of requirements and scheduling into increments. Ability to prioritize requirements and schedule them into increments based on considerations of:

(a) Stakeholder priorities and returns on investment

(b) Capability interdependencies and requirements emergence considerations

(c) Technology maturity and implementation feasibility risks

Goal 2. System Life Cycle Organization, Planning, Staffing

CSF 2.1 Establishment of stakeholder life cycle RAAs for system definition, system development, and system operation. Ability to support establishment of stakeholder RAAs via conduct of:

(a) Organizational capability analyses

(b) Stakeholder negotiations

(c) Operational exercise analyses

CSF 2.2 Establishment of Integrated Product Team (IPT) RAAs, Cross-IPT coordination needs. Ability to establish IPT RAAs and cross-IPT coordination mechanisms via:

(a) Risk identification, analysis, and prioritization

(b) Organizational RAAs and skills availability assessment

(c) Risk interdependency analysis

(d) Risk resolution cost-benefit analysis

CSF 2.3 Establishment of necessary resources for meeting objectives. Ability to support program negotiation of objectives vs. resources via:

(a) Cost-schedule-capability tradeoff analyses

(b) Use of requirements priorities and interdependencies to support negotiation of increment contents

(c) Development of strategies to adjust increment content to meet delivery schedules

(d) Analysis of project change traffic and rebaselining of future-increment plans and specifications

CSF 2.4 **Establishment and usage support of appropriate source selection, contracting, & incentive structures. Ability to support program management in preparing source selection materials, matching contracting and incentive structures to program objectives, and technical monitoring of performance vs. program objectives:**

(a) Preparation of proposal solicitation materials and evaluation capabilities and procedures

(b) Evaluation of proposal submissions with respect to criteria

(c) Technical support of contract negotiations

(d) Technical support of contract performance monitoring

CSF 2.5 **Assurance of necessary personnel competencies. Ability to support program management in evaluating proposed staffing plans and monitoring staffing capabilities vs. plans in the areas of:**

(e) Concurrent Definition of System Requirements & Solutions

(f) System Life Cycle Organization, Planning, Staffing

(g) Technology Maturing and Architecting

(h) Evidence-Based Progress Monitoring & Commitment Reviews

(i) Professional and Interpersonal Skills

Goal 3. **Technology Maturing and Architecting**

CSF 3.1 **COTS/NDI/Services evaluation, selection, validation for capability, maturity & compatibility. Ability to evaluate alternative combinations of COTS, NDI, and purchased services for:**

(a) Functional capabilities vs. system needs

(b) Levels of service: performance, resilience, scalability, usability, tailorability, etc.

(c) Mutual compatibility and external interoperability

(d) Supplier maturity, stability, support, and responsiveness

(e) Acquisition and operational costs

CSF 3.2 Life Cycle architecture definition & validation. Ability to define and evolve configurations of hardware and software components and connectors along with human operational architectures, and to validate that they cost-effectively support program objectives:

(a) Define candidate hardware/software/human-operational architectures

(b) Evaluate their functional capabilities, levels of service, interoperability, and sustainability vs. system needs

(c) Perform tradeoff analyses among functional capabilities and levels of service

CSF 3.3 Use of prototypes, exercises, models, and simulations to determine technology maturity, architecture feasibility. Ability to assess the relative costs and benefits of alternative evaluation methods, and apply appropriate combinations of methods:

(a) Assess relative costs, schedules, and capabilities of various combinations of evaluation methods

(b) Prepare plans for enabling and performing evaluations

(c) Prepare representative nominal and off-nominal scenarios, workload generators, virtual component surrogates, and testbeds to support evaluations

(d) Perform evaluations, analyze results, investigate anomalies, and adjust plans as appropriate

CSF 3.4 Validated System Engineering, Development, Manufacturing, Operations & Maintenance budgets & schedules. Ability to:

(a) Assess alternative budget and schedule estimation methods vs. nature of system, degree of system knowledge, complementarity of estimates, and cost vs. accuracy of performing estimates

(b) Prepare plans for gathering inputs and performing estimates

(c) Perform selected combinations of estimates and reconcile their differences

(d) Perform tradeoff analyses among functional capabilities, levels of service, costs, and schedules

Goal 4. Evidence-Based Progress Monitoring & Commitment Reviews

CSF 4.1 Monitoring of system definition, development, and test progress vs. plans. Ability to plan, monitor, and evaluate technical progress vs. plans

(a) Prepare test and evaluation facilities and plans, and define data to be provided for assessing technical progress vs. project plans

(b) Monitor performers' technical progress in developing, verifying, and validating their technical solutions

(c) Identify shortfalls in technical progress vs. plans, and determine their root causes

CSF 4.2 Monitoring of feasibility evidence development and test progress vs. plans. Ability to:

(a) Evaluate developers' feasibility evidence assessment and test plans for coverage, cost-effectiveness, and realism of assumptions

(b) Monitor developers' progress with respect to plans, identify shortfalls and root causes

(c) Evaluate feasibility evidence produced, identify shortfalls and root causes

CSF 4.3 Monitoring, assessment, and replanning for changes in needs, opportunities, and resources. Ability to:

(a) Assess proposed changes in program objectives, constraints, plans, and resources

(b) Perform triage to determine which changes should be handled immediately, deferred to future increments, or rejected

(c) Perform tradeoff analyses to support renegotiation of current and future increment plans and contents

(d) Validate feasibility and cost-effectiveness of renegotiated increment plans and contents

(e) Monitor effectiveness of configuration and version management

CSF 4.4 Identification and mitigation planning for feasibility evidence shortfalls and other risks. Ability to recommend corrective actions for feasibility evidence shortfalls and other risks

(a) Identify and evaluate alternative courses of action to address feasibility evidence shortfalls, technical risks, and root causes

(b) Recommend appropriate corrective actions to obtain best-possible system outcomes

CSF 4.5 Use of milestone reviews to ensure stakeholder commitment to proceed. Ability to:

(a) Prepare plans, schedules, budgets, scenarios, and facilities for evaluating developer feasibility evidence

(b) Identify shortfalls in feasibility evidence as program risks

(c) Assess developer risk management plans for coverage of risks, identify shortfalls, and recommend corrective actions

Goal 5. Professional and Interpersonal Skills

CSF 5.1 Leadership. Ability to plan, staff, organize, teambuild, control, and direct systems engineering teams

(a) Prepare top-level plans, schedules, budgets, and deliverables for a system engineering team

(b) Evaluate and recruit appropriate staff members for executing plans

(c) Involve staff members in collaborative development of team shared vision, detailed plans, and organizational roles; adjust top-level plans as appropriate

(d) Monitor progress with respect to plans, identify shortfalls, provide mentoring and constructive corrective actions to address shortfalls

CSF 5.2 Collaboration. Ability to work with others to negotiate, plan, execute, and coordinate complementary tasks for achieving program objectives

(a) Develop understanding of other participants' value propositions, and use knowledge to negotiate mutually satisfactory roles, responsibilities, and modes of collaboration

(b) Establish modes of pro-active coordination of emerging issues with other team members and teams

(c) Provide help to others in need of your capabilities

CSF 5.3 Communication. Ability to perform timely, coherent, and concise verbal and written communication

(a) Develop understanding of other participants' knowledge boundaries and terminology, and adjust your terminology to facilitate their understanding of your communications

(b) Provide timely, coherent, and concise verbal and written communication within your team and among external stakeholders

(c) Explore new low-tech (wallboards) and high-tech (wikis, blogs, videos) modes of effective communications

CSF 5.4 Accountability. Ability to deliver on promises and behave ethically

(a) Commit to and follow through on promised commitments; provide advance warning of potential delays and shortfalls

(b) Respect the truth, intellectual property, and the rights and concerns of others

CSF 5.5 Adaptability and Leaning. Ability to cope with uncertainty and unexpected developments, and to seek help and fill relevant knowledge gaps

(a) Be prepared to cope with inevitable uncertainty and unexpected developments

(b) Identify key knowledge and skills needed for your project and career, and engage in learning activities to master them

APPENDIX B: SEPRT EXAMPLE – LOGISTICS SUPPORT SYSTEM PROJECT

NOTE: Impact and evidence/risk ratings should be done independently. The impact rating should estimate the effect a failure to address the specified item might have on the program. The evidence rating should specify the qualtity of evidence that has been provided, which demonstrates that the specified risk item has been satisfactorily addressed.

Exposure	Question #	Impact: High	Impact: Medium	Impact: Low	Impact: No impact	Evidence/Risk: No evidence Hig risk	Evidence/Risk: Some evidence	Evidence/Risk: Good evidence	Evidence/Risk: Ext. validated		Risk Exposure	Rationale/ Source of evidence
Goal 1:						**Concurrent definition of system requirements and solutions**						
	Critical Success Factor 1.1									**Understanding of stakeholder needs: capabilities, operational concept, key performance parameters, enterprise fit (legacy)**	2	
1	**1.1(a)**	○	○	○	●	●	○	○	○	At Milestone A, have the KPPs been identified in clear, comprehensive, concise terms that are understandable to the users of the system?		No formal Milestone A
2	**1.1(b)**	○	○	●	○	○	●	○	○	Has a CONOPS been developed showing that the system can be operated to handle both nominal and off-nominal workloads, and to meet response time requirements?		IT system sized using vendor benchmarks and expected number of users
2	**1.1(c)**	○	○	●	○	○	●	○	○	Has the ability of the system to meet mission effectiveness goals been verified through the use of modeling and simulation?		IT system designed to replace legacy system and manual processes. Mission effectiveness of system not a major concern during development.
2	**1.1(d)**	●	○	○	○	○	○	●	○	Have the success-critical stakeholders been identified and their roles and responsibilities negotiated?		Development of system had been attempted by other companies and failed. Stakeholders had been previous identified and were involved early on.
2	**1.1(e)**	●	○	○	○	○	○	●	○	Have questions about the fit of the system into the stakeholders' context -- acquirers, end users, administrators, interoperators, maintainers, etc. -- been adequately explored?		Explored across all areas early on. However, new sponsor IT PM (assigned to project after system acceptance but before deployment) changed system requirements related to database system and there was no funding left to migrate to a different DBMS.
	Critical Success Factor 1.2									**Concurrent exploration of solution opportunities; analysis of alternatives (AoAs) for cost-effectiveness and risk (measures of effectiveness)**	2	
2	**1.2(a)**	○	●	○	○	○	●	○	○	Have at least two alternative approaches been explored and evaluated?		Was recommended, but rejected by sponsor PM due to "color of money" (legacy replacement needed to remain on upgraded legacy platform)
2	**1.2(b)**	○	●	○	○	○	○	●	○	At Milestone B, has the government structured the program plan to ensure that the contractor addresses the allocation of capabilities to hardware, software, and human elements sufficiently early in the development program?		
1	**1.2(c)**	○	○	○	●	●	○	○	○	Has the claimed degree of reuse been validated?		No planned reuse (unless you consider use of GUI builder "reuse". In this case, none initially planned, but change in

2	1.2(d)	Have the claimed quality of service guarantees been validated?		Vendor platform benchmarks used
2	1.2(e)	Have proposed COTS and third-party solutions been validated for maturity, compatibility, supportability, suitability, and effectiveness, throughout the expected system lifetime?		GUI prototype developed and demo'd prior to finalizing the decision to use the GUI builder.
	Critical Success Factor 1.3	**System scoping & requirements definition (external interfaces; memoranda of agreement)**	2	Not clear why this was yellow based on response to first subitem (High Impact, Good Evidence)--Also stayed yellow after response to 2nd subitem
2	1.3(a)	Have external interface complexities been identified and minimized via MoAs or their equivalent? Is there a plan to mitigate their risks?		External interfaces well defined and used by legacy system being replaced.
2	1.3(b)	At Milestone B, are the major system-level requirements (including all KPPs) defined sufficiently to provide a stable basis for the development through IOC?		
1	1.3(c)	By Milestone A, is there a plan to have information exchange protocols established for the whole system and its segments by Milestone B?		N/A--no formal Milestone A and system used well-defined, existing protocols for external interfaces.
	1.3(d)	Have the key stakeholders agreed on the system boundary and assumptions about its environment?		Based on current business processes and documented in system requirements
	Critical Success Factor 1.4	**Prioritization of requirements & allocation to increments**	2	
2	1.4(a)	Can an initial capability be achieved within the time that the key program leaders are expected to remain engaged in their current jobs (normally less than 5 years or so after Milestone B)? If this is not possible for a complex major development program, can critical subsystems, or at least a key subset of them, be demonstrated within that time frame?		This was not initially perceived as a high impact, but turned out to be a high impact. System was developed, accepted, and entered OT&E under a single program leader, but leader was replaced prior to deployment and subsequent leader decided that she did not want to deploy the system since it did not use her "preferred" DBMS.
2	1.4(b)	At Milestone B, do the requirements take into account likely future mission growth over the program life cycle?		Some initial problems during OT&E due to the fact that developers had not anticipated how often users would resend transactions and users had request that ALL transactions be saved online. Quick fix initiated during OT&E when storage capacity of system exceeded.
2	1.4(c)	Have appropriate early evaluation phases, such as competitive prototyping, been considered or executed for high-risk/low-maturity components of the system?		
	1.4(d)	Have stakeholders agreed on prioritization of system features and their allocation to development increments?		Single increment on fixed price contract.

Goal 2:	System life-cycle organization, planning, and staffing		

Critical Success Factor 2.1 — **Establishment of stakeholder life-cycle responsibilities, authorities, and accountabilities (RAAs) (for system definition & system development)** — 2

Rating	Item	Question	Evidence
2	2.1(a)	Are the stakeholders who have been identified as critical to the success of the project represented by highly qualified personnel -- those who are collaborative, representative, authorized, committed, and knowledgeable?	System developed for small organization and all key users and associated managers identified as stakeholders and actively participated in the development process.
1	2.1(b)	At Milestone A, are there validated plans, budgets, and schedules defining how the pre-Milestone B activity will be done, and by whom?	No formal Milestone A
2	2.1(c)	Has the government attempted to align the duration of the program manager's assignment with key deliverables and milestones in the program?	PM lasted through acceptance testing and into OT&E
	2.1(d)	Have the key stakeholders agreed to the proposed assignments of system roles, responsibilities, and authorities?	Initial assessed impact low, but turned out to be high when users realized that their job was at risk since the new system automated much of their job, resulting in them sabotaging the deployment of the system (along with the new PM).

Critical Success Factor 2.2 — **Establishment of integrated product team (IPT) RAAs, cross-IPT coordination needs** — 1

Rating	Item	Question	Evidence
1	2.2(a)	Does the project make effective use of Integrated Project Teams (IPTs) throughout the supplier hierarchy?	N/A--small agile-like team
	2.2(b)	Are the IPTs staffed by highly qualified personnel, as in 2.a(a)?	N/A
	2.2(c)	For IPTs addressing strongly coupled objectives, are there "super-IPTs" for resolving conflicts among the objectives?	N/A

Critical Success Factor 2.3 — **Establishment of necessary plans and resources for meeting objectives** — 3

Rating	Item	Question	Evidence
2	2.3(a)	Have decisions about the use of one-shot, incremental, or evolutionary development been validated for appropriateness and feasibility, and accepted by the key stakeholders?	Project designed to be single increment FFP contract. When development team brought on and began to validate initial plans, realized that the project was not do-able and investigated alternatives, resulting in an Ada waiver, the use of a GUI builder, and a small "agile" development team (that also produced 2167A deliverables).
3	2.3(b)	Have system definition, development, test, and evolution plans, budgets, and schedules been validated for appropriateness and feasibility, and accepted by the key stakeholders?	Not clear what better evidence would be. Initial plans adjusted and presented to key stakeholders at requirements review, PDR, and CDR, with prototype demo presented by PDR. COCOMO cost model not useful due to nature of development using GUI builder (pre-COCOMO II)
2	2.3(c)	Is there a valid business case for the system, relating the life cycle system benefits to the system total cost of ownership?	

Critical Success Factor 2.4

Establishment of appropriate source selection, contracting, and incentive structures

2

Rating	Item	Question	Comment
	2.4(a)	Has the competitive prototyping option been addressed, and the decision accepted by key stakeholders?	N/A--system developed using known technologies and products
	2.4(b)	If doing competitive prototyping, have adequate plans and preparations been made for exercising and evaluating the prototypes, and for sustaining core competitive teams during evaluation and down selection?	
2	2.4(c)	Is the status of the contractor's business and team "healthy," both in terms of business indicators, and within the industrial base for the program area? Is the program aligned with the core business of the unit, and staffed adequately and appropriately?	Contractor's established team at company headquarters started the development, then transitioned development to the customer's location after hiring new staff for the local office. New hires were well-vetted and intially worked with headquarter's team through a transition period. Not clear what other evidence one would look for.
2	2.4(d)	Has the acquiring organization successfully completed projects similar to this one in the past?	This project did not need to employ "rocket science". It was a fairly typically IT system with some key, but well-understood, external interfaces.
2	2.4(e)	Has the candidate performing organization successfully completed projects similar to this one in the past?	This project did not need to employ "rocket science". It was a fairly typically IT system with some key, but well-understood, external interfaces.
	2.4(f)	Is the program governance process, and in particular the system engineering plan, well articulated and compatible with the goals of the program?	No SEP was required for this progam (well below the MDAP threshold)

Critical Success Factor 2.5

Establishment of necessary personnel competencies

3

Rating	Item	Question	Comment
2	2.5(a)	Does the government have access over the life of the program to the talent required to manage the program? Does it have a strategy over the life of the program for using the best people available in the government, the FFRDCs, and the professional service industry?	***Yellow risk button not enabled here.*** In response to questions, sponsor PM was a computer scientist with IT experience.
3	2.5(b)	At Milestone B, have sufficiently talented and experienced program and systems engineering managers been identified? Have they been empowered to tailor processes and to enforce development stability from Milestone B through IOC?	Potentially high impact due to the FFP nature of the contract. Not sure what "good" or "externally validated" evidence is here. People selected in the headquarter's office were "known quantities" within the development organization and staffed the project with a new team at the customer's location. New staff were interviewed and references checked. However, I would not call this "externally validated" since it is known that references are hesitant to say anything negative due to the fear of lawsuits.
2	2.5(c)	Has the government attempted to align the duration of the program manager’s assignment with key deliverables and milestones in the program?	Not a major issue since the program was only scheduled for about 18 months.
1	2.5(d)	Is the quantity of systems engineering personnel assigned, their skill and seniority mix, and the time phasing of their application throughout the program life cycle appropriate?	Not really a major issue for an IT application using COTS products.

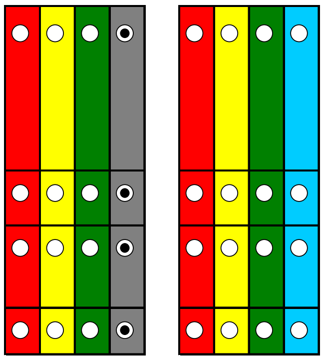
Goal 3: **Technology maturing, architecting**

	Critical Success Factor 3.1	COTS/NDI/Services evaluation, selection, validation for maturity & compatibility	1
1	3.1(a)	Have COTS/NDI/Services opportunities been evaluated prior to baselining requirements?	Proposed COTS were established products
1	3.1(b)	Have COTS/NDI/Services scalability, compatibility, quality of service, and life cycle support risks been thoroughly addressed?	At the time the products were selected, they were probably adequately evaluated. However, a few years later, ORACLE drove several other DBMS products out of the market place. Not clear that could have been anticipated at the time since ORACLE was going through some growing pains at the time this project was initiated. In addition, options were limited due to the "color of money" and ORACLE was not thought to be a candidate since the legacy system was not built upon ORACLE.
1	3.1(c)	Has a COTS/NDI/Services life cycle refresh strategy been developed and validated?	Seemed reasonable at the time since an established vendor was used.

	Critical Success Factor 3.2	Life-cycle architecture definition & validation	2
1	3.2(a)	Has the system been partitioned to define segments that can be independently developed and tested to the greatest degree possible?	Basis for work assignments across the programming team.
1	3.2(b)	By Milestone A, is there a plan to have internal and external information exchange protocols established for the whole system and its segments by Milestone B?	Used existing protocols implemented in legacy system
2	3.2(c)	Does the project have adequate processes in place to define the verification, test & validation, and acceptance of systems and system elements at all phases of definition and development?	The "evidence" seemed reasonable since subject matter experts from a subcontractor organization were used and the prime supported the development of the test plan and procedure documentation.
2	3.2(d)	Is there a clear, consistent, and traceable relationship between system requirements and architectural elements? Have potential off-nominal architecture-breakers been addressed?	Not really an issue with this IT system
	3.2(e)	Does the architecture adequately reconcile functional hardware "part-of" hierarchies with layered software "served-by" hierarchies?	Not really an issue with this IT system
	3.2(f)	Has a Work Breakdown Structure (WBS) been developed with the active participation of all relevant stakeholders, which accurately reflects both the hardware and the software product structure?	Not really an issue with this IT system--all hardward was standard COTS

Critical Success Factor 3.3

Use of prototypes, exercises, models, and simulations to determine technological solution maturity

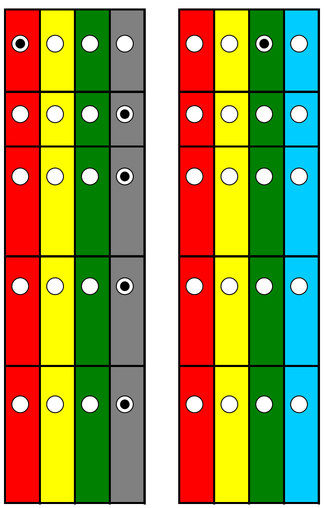


3.3(a)	Will risky new technology mature before Milestone B? Is there a risk mitigation plan?	Contract was awarded at Milestone B with plan to use no new technologies. When it was decided to use a new-on-the-market GUI builder after contract award, the tool was tested during the development of the user I/F prototype before a final decision was made.
3.3(b)	Have the key non-technical risk drivers been identified and covered by risk mitigation plans?	
3.3(c)	Is there a sufficient collection of models, and appropriate simulation and exercise environments, to validate the selected concept and the CONOPS against the KPPs?	Not really an issue with this IT system. The user I/F was prototyped and evaluated by the key users prior to completion of PDR.
3.3(d)	Has the claimed degree of reuse been validated?	No reuse was initially planned (is this a duplicate question?)

Critical Success Factor 3.4

Validated system engineering, development, manufacturing, operations & maintenance budgets and schedules

2



2	3.4(a)	Are the major known cost and schedule drivers and risks explicitly identified, and is there a plan to track and reduce uncertainty?	High impact due to FFP nature of contract, but were identified and managed well early-on
	3.4(b)	Have the cost confidence levels been developed and accepted by the key system stakeholders?	Total cost was negotiated prior to contract award.
	3.4(c)	Is there a top-to-bottom plan for how the total system will be integrated and tested? Does it adequately consider integration facilities development and earlier integration testing?	Development lab provided at contractor's facility that supported both development and test. This was established prior to development contract award.
	3.4(d)	If time-boxing or time-determined development is used to stabilize schedules, have features been prioritized and the system architected for ease of adding or dropping borderline features?	N/A due to single increment
	3.4(e)	Are there strategies and plans for evolving the architecture while stabilizing development and providing continuity of services?	Not really an issue with an IT/DBMS-based application. What might have been more of an issue was the underlying data model, but most data elements, tables, user forms were well defined early-on.

Goal 4: **Evidence-based progress monitoring and commitment reviews**

Rating	Item	Question	Comment
	Critical Success Factor 4.1	**Monitoring of system definition & development progress vs. plans**	2
2	**4.1(a)**	Are the levels and formality of plans, metrics, evaluation criteria, and associated mechanisms (IMP, IMS, WBS, EVMS) commensurate with the level of project requirements emergence and stability? (Too little is risky for pre-specifiable and stable requirements; too much is risky for emergent and unstable requirements.)	Level of formality may have been excessive for project. However, due to the FFP nature of the contract, the development organization used corporate standards for risky programs to monitor this program.
2	**4.1(b)**	Are the project's staffing plans and buildup for progress monitoring adequate with respect to required levels of expertise?	
2	**4.1(c)**	Have most of the planned project personnel billets been filled with staff possessing at least the required qualification level?	
2	**4.1(d)**	Is the project adequately identifying and managing its risks?	
2	**4.1(e)**	Have the processes for conducting reviews been evaluated for feasibility, reasonableness, completeness, and assurance of independence?	
2	**4.1(f)**	Has compliance with legal, policy, regulatory, standards, and security requirements been clearly demonstrated?	
	Critical Success Factor 4.2	**Monitoring of feasibility evidence development progress vs. plans**	2
2	**4.2(a)**	Has the project identified the highest risk areas on which to focus feasibility analysis?	GUI environment
2	**4.2(b)**	Has the project analyzed alternative methods of evaluating feasibility (models, simulations, benchmarks, prototypes, reference checking, past performance, etc.) and prepared the infrastructure for using the most cost-effective choices?	See above
1	**4.2(c)**	Has the project identified a full set of representative operational scenarios across which to evaluate feasibility?	
2	**4.2(d)**	Has the project prepared milestone plans and earned value targets for measuring progress in developing feasibility evidence?	
2	**4.2(e)**	Is the project successfully monitoring progress and applying corrective action where necessary?	

Critical Success Factor 4.3

Monitoring, assessment, and replanning for changes in needs, opportunities, and resources

2

1	**4.3(a)**	Does the project have an effective strategy for performing triage (accept, defer, reject) on proposed changes, which does not destabilize ongoing development?	Strategy defined, but seldom used on project
2	**4.3(b)**	Does the project have an adequate capability for performing change impact analysis and involving appropriate stakeholders in addressing and prioritizing changes?	Process detined, but seldom used on project
2	**4.3(c)**	Is the project adequately verifying and validating proposed changes for feasibility and cost-effectiveness?	Only received a couple of change requests during project

Critical Success Factor 4.4

Use of milestone reviews to ensure stakeholder commitment to proceed

2

2	**4.4(a)**	Are milestone review dates based on the availability of feasibility evidence, instead of the availability of artifacts or the occurrence of planned review dates?	
2	**4.4(b)**	Are artifacts and evidence of feasibility evaluated, and risky shortfalls identified, by key stakeholders and independent experts, prior to review events?	
2	**4.4(c)**	Are developer responses to identified risks prepared prior to review events?	
2	**4.4(d)**	Do reviews achieve risk-based concurrence of key stakeholders on whether to proceed into the next phase? (Proceed; skip a phase; revisit the current phase; terminate or rescope the project.)	Not an option after FFP contract issued

APPENDIX C: SECRT EXAMPLE – LOGISTICS SUPPORT SYSTEM PROJECT

Exposure	Question #	Impact: High	Impact: Medium	Impact: Low	Impact: No impact	Competency/Risk: No experience Hig risk	Competency/Risk: Some experience	Competency/Risk: Good experience	Competency/Risk: Expert experience	NOTE: Impact and evidence/risk ratings should be done independently. The impact rating should estimate the effect a failure to competently address the specified item might have on the program. The competency rating should specify the observed, historical experience and competency of the systems engineering staff on past programs with respect to the specified risk item.	Risk Exposure	Rationale/ Source of evidence
Goal 1:										**Concurrent definition of system requirements and solutions**		
	Critical Success Factor 1.1									**Understanding of stakeholder needs: capabilities, operational concept, key performance parameters, enterprise fit (legacy). Ability to analyze strengths and shortfalls in current-system operations via:**	2	
2	**1.1(a)**	◉	○	○	○	○	○	◉	○	Participatory workshops, surveys, focus groups		
2	**1.1(b)**	○	◉	○	○	○	◉	○	○	Operations research techniques: operations data collection and analysis		
2	**1.1(c)**	○	○	◉	○	○	◉	○	○	Mission effectiveness modeling and simulation		
2	**1.1(d)**	○	◉	○	○	○	○	◉	○	Prototypes, scenarios, stories, personas		
2	**1.1(e)**	○	◉	○	○	○	◉	○	○	Ethnographic techniques: Interviews, sampled observations, cognitive task analysis		
	Critical Success Factor 1.2									**Concurrent exploration of solution opportunities; analysis of alternatives (AoAs) for cost-effectiveness and risk (measures of effectiveness). Ability to identify and assess alternative solution opportunities via experimentation and analysis of:**	2	
2	**1.2(a)**	○	◉	○	○	○	◉	○	○	Alternative work procedures, non-materiel solutions		
2	**1.2(b)**	○	◉	○	○	○	○	◉	○	Purchased or furnished products and services		Limited by color of money
2	**1.2(c)**	○	○	◉	○	○	◉	○	○	Emerging technology		Limited by color of money
	1.2(d)	○	○	○	◉	○	○	○	○	Competitive prototyping		Not prior to contract award. Project too small
	Critical Success Factor 1.3									**System scoping & requirements definition (external interfaces; memoranda of agreement). Ability to establish system scope and requirements via:**	2	
2	**1.3(a)**	○	◉	○	○	○	○	◉	○	Cost-schedule-effectiveness assessment of needs vs. opportunities		
2	**1.3(b)**	○	○	◉	○	○	◉	○	○	Organizational responsibilities, authorities, and accountabilities (RAAs) assessment		
2	**1.3(c)**	◉	○	○	○	○	○	◉	○	Appropriate degrees of requirements completeness, consistency, testability, and variability due to emergence considerations		

	Critical Success Factor 1.4	**Prioritization of requirements & allocation to increments. Ability to prioritize requirements and schedule them into increments based on considerations of:**		Incremental delivery not an option. Project too small.
	1.4(a)	Stakeholder priorities and returns on investment		
	1.4(b)	Capability interdependencies and requirements emergence considerations		
	1.4(c)	Technology maturity and implementation feasibility risks		
	Goal 2:	**System life-cycle organization, planning, and staffing**		
	Critical Success Factor 2.1	**Establishment of stakeholder life-cycle responsibilities, authorities, and accountabilities (RAAs) (for system definition & system development). Ability to support establishment of stakeholder RAAs via conduct of:**		Well established in sponsor IT group
	2.1(a)	Organizational capability analyses		
	2.1(b)	Stakeholder negotiations		
	2.1(c)	Operational exercise analyses		
	Critical Success Factor 2.2	**Establishment of integrated product team (IPT) RAAs, cross-IPT coordination needs. Ability to establish IPT RAAs and cross-IPT coordination mechanisms via:**		Not really done due to size of project, small team co-located, with considerable inputs from stakeholders.
	2.2(a)	Risk identification, analysis, and prioritization		
	2.2(b)	Organizational RAAs and skills availability assessment		
	2.2(c)	Risk interdependency analysis		
	2.2(d)	Risk resolution cost-benefit analysis		
	Critical Success Factor 2.3	**Establishment of necessary resources for meeting objectives. Ability to support program negotiation of objectives vs. resources via:**	2	Not much negotiation after award of FFP contract. However, some negotions conducted in order to incorporate new higher priority requirement and drop lower priority requirements for a no-cost change.
2	**2.3(a)**	Cost-schedule-capability tradeoff analyses		
2	**2.3(b)**	Use of requirements priorities and interdependencies to support negotiation of increment contents		
	2.3(c)	Development of strategies to adjust increment content to meet delivery schedules		
	2.3(d)	Analysis of project change traffic and rebaselining of future-increment plans and specifications		No future increments planned

Critical Success Factor 2.4

Establishment of appropriate source selection, contracting, and incentive structures. Ability to support program management in preparing source selection materials, matching contracting and incentive structures to program objectives, and technical monitoring of performance vs. program objectives:

N/A due to size of project. Project done under an "umbrella" services contract.

	2.4(a)	○	○	○	○	○	○	○	○	Preparation of proposal solicitation materials and evaluation capabilities and procedures
	2.4(b)	○	○	○	○	○	○	○	○	Evaluation of proposal submissions with respect to criteria
	2.4(c)	○	○	○	○	○	○	○	○	Technical support of contract negotiations
	2.4(d)	○	○	○	○	○	○	○	○	Technical support of contract performance monitoring

Critical Success Factor 2.5

Assurance of necessary personnel competencies. Ability to support program management in evaluating proposed staffing plans and monitoring staffing capabilities vs. plans in the areas of:

Good staff on project, but system requirements/solution approach already established by contract award. Probably done in large part by the government.

	2.5(a)	○	○	○	○	○	○	○	○	Concurrent definition of system requirements & solutions
	2.5(b)	○	○	○	○	○	○	○	○	System life -cycle organization, planning, and staffing
	2.5(c)	○	○	○	○	○	○	○	○	Technology maturing and architecting
	2.5(d)	○	○	○	○	○	○	○	○	Evidence-based progress monitoring & commitment reviews
	2.5(e)	○	○	○	○	○	○	○	○	Professional and interpersonal skills

Goal 3: Technology maturing, architecting

Critical Success Factor 3.1

COTS/NDI evaluation, selection, validation for maturity & compatibility. Ability to evaluate alternative combinations of COTS, NDI, and purchased services for:

2

Key was identification of GUI builder to eliminate Ada requirment for interactive database application.

2	3.1(a)	●	○	○	○	○	○	●	○	Functional capabilities vs. system needs
2	3.1(b)	○	●	○	○	○	●	○	○	Levels of service: performance, resilience, scalability, usability, tailorability, etc.
	3.1(c)	○	○	○	●	○	○	○	○	Mutual compatibility and external interoperability
2	3.1(d)	○	●	○	○	○	○	●	○	Supplier maturity, stability, support, and responsiveness
	3.1(e)	○	○	○	○	○	○	○	○	Acquisition and operational costs

Done using vendor benchmarks. Selection of vendor limited due to color of money for COTS/NDI not an issue as long as network connectivity allowed

Not clear how to rate this given above constraints

Score	Item	Description	Score	Comment
	Critical Success Factor 3.2	**Life-cycle architecture definition & validation. Ability to define and evolve configurations of hardware and software components and connectors along with human operational architectures, and to validate that they cost-effectively support program objectives:**		Only one hardware configuration based on COTS
	3.2(a)	Define candidate hardware/software/human-operational architectures		
	3.2(b)	Evaluate their functional capabilities, levels of service, interoperability, and sustainability vs. system needs		
	3.2(c)	Perform tradeoff analyses among functional capabilities and levels of service		
	Critical Success Factor 3.3	**Use of prototypes, exercises, models, and simulations to determine technological solution maturity. Ability to assess the relative costs and benefits of alternative evaluation methods, and apply appropriate combinations of methods:**	2	Done with respect to GUI builder
2	**3.3(a)**	Assess relative costs, schedules, and capabilities of various combinations of evaluation methods		
2	**3.3(b)**	Prepare plans for enabling and performing evaluations		
	3.3(c)	Prepare representative nominal and off-nominal scenarios, workload generators, virtual component surrogates, and testbeds to support evaluations		Not reasonable for small project
2	**3.3(d)**	Perform evaluations, analyze results, investigate anomalies, and adjust plans as appropriate		Not done with any rigor due to size of project/schedule
	Critical Success Factor 3.4	**Validated system engineering, development, manufacturing, operations & maintenance budgets and schedules. Ability to:**	3	Manufacturing n/a. Operations not within scope of contract--government to assume operations and maintenance at end of contract using existing staff maintaining/operating system being replace.
	3.4(a)	Assess alternative budget and schedule estimation methods vs. nature of system, degree of system knowledge, complementarity of estimates, and cost vs. accuracy of performing estimates		
2	**3.4(b)**	Prepare plans for gathering inputs and performing estimates		
3	**3.4(c)**	Perform selected combinations of estimates and reconcile their differences		
	3.4(d)	Perform tradeoff analyses among functional capabilities, levels of service, costs, and schedules		Not an option

Goal 4:	**Evidence-based progress monitoring and commitment reviews**

	Critical Success Factor 4.1	**Monitoring of system definition, development, & test progress vs. plans. Ability to plan, monitor, and evaluate technical progress vs. plans:** 2
2	**4.1(a)**	Prepare test & evaluation facilities & plans and define data to be provided for assessing technical progress vs. project plans
1	**4.1(b)**	Monitor performers' technical progress in developing, verifying and validating their technical solutions
1	**4.1(c)**	Identify shortfalls in technical progress vs. plans, and determine their root causes
	Critical Success Factor 4.2	**Monitoring of feasibility evidence development and test progress vs. plans. Ability to:**
	4.2(a)	Evaluate developers' feasibility evidence assessment and test plans for coverage, cost-effectiveness, and realism of assumptions
	4.2(b)	Monitor developers' progress with respect to plans, identify shortfalls and root causes
	4.2(c)	Evaluate feasibility evidence produced, identify shortfalls and root causes
	Critical Success Factor 4.3	**Monitoring, assessment, and replanning for changes in needs, opportunities, and resources. Ability to:**
	4.3(a)	Assess proposed changes in program objectives, constraints, plans, and resources
	4.3(b)	Perform triage to determine which should be handled immediately, deferred to future increments, or rejected
	4.3(c)	Perform tradeoff analyses to support renegotiation of current and future increment plans and contents
	4.3(d)	Validate feasibility and cost-effectiveness of renegotiated increment plans and contents
	4.3(e)	Monitor effectiveness of configuration and version management
	Critical Success Factor 4.4	**Identification and mitigation planning for feasibility evidence shortfalls and other technical risks. Ability to recommend corrective actions for feasibility evidence shortfalls and technical risks:**
	4.4(a)	Identify and evaluate alternative courses of action to address feasibility evidence shortfalls, technical risks, and root causes
	4.4(b)	Recommend appropriate corrective actions to obtain best-possible system outcomes

Critical Success Factor 4.5 — **Use of milestone reviews to ensure stakeholder commitment to proceed.**

Ability to:

4.5(a)	Prepare plans, schedules, budgets, scenarios, tools, and facilities for evaluating developer feasibility evidence
4.5(b)	Identify shortfalls in feasibility evidence as program risks
4.5(c)	Assess developer risk management plans for coverage of risks, identify shortfalls, and recommend corrective actions

Goal 5: Professional and interpersonal skills

Critical Success Factor 5.1 — **Leadership. Ability to plan, staff, organize, teambuild, control, and direct systems engineering teams.**

5.1(a)	Prepare top-level plans, schedules, budgets, and deliverables for a system engineering team
5.1(b)	Evaluate and recruit appropriate staff members for executing plans
5.1(c)	Involve staff members in collaborative development of team shared vision, detailed plans, and organizational roles; adjust top-level plans as appropriate
5.1(d)	Monitor progress with respect to plans, identify shortfalls, provide mentoring and constructive corrective actions to address shortfalls

Critical Success Factor 5.2 — **Collaboration. Ability to work with others to negotiate, plan, execute, and coordinate complementary tasks for achieving program objectives**

5.2(a)	Develop understanding of other participants' value propositions, and use knowledge to negotiate mutually satisfactory roles, responsibilities, and modes of collaboration
5.2(b)	Establish modes of pro-active coordination of emerging issues with other team members and teams
5.2(c)	Provide help to others in need of your capabilities

Critical Success Factor 5.3 — **Communication. Ability to perform timely, coherent, and concise verbal and written communication**

5.3(a)	Develop understanding of other participants' knowledge boundaries and terminology, and adjust your terminology to facilitate their understanding of your communications
5.3(b)	Provide timely, coherent, and concise verbal and written communication within your team and among external stakeholders
5.3(c)	Explore new low-tech (wallboards) and high-tech (wikis, blogs, videos) modes of effective communications

General comment on tool overall: Too detailed and too subject to interpretation. It depends on who is going to do the evaluation and what criteria they are using. It also depends upon the size and scope of the project. For example, it will be difficult for someone who does not already know the staff to evaluate accountability... and an organization is not typically going to divulge the fact that they don't think all of their staff are accountable/ethical.

Critical Success Factor 5.4 — **Accountability. Ability to deliver on promises and behave ethically**

5.4(a) Commit to and follow through on promised commitments; provide advance warning of potential delays and shortfalls

5.4(b) Respect the truth, intellectual property, and the rights and concerns of others

Critical Success Factor 5.5 — **Adaptability and Learning. Ability to cope with uncertainty and unexpected developments, and to seek help and fill relevant knowledge gaps**

5.5(a) Be prepared to cope with inevitable uncertainty and unexpected developments

5.5(b) Identify key knowledge and skills needed for your project and career, and engage in learning activities to master them

APPENDIX D: BASIC COVERAGE MATRIX

	SERC EM Task Coverage Matrix V1.0								
		NRC	**Probability of Success**	**SE Leading Indicators**	**LIPSF (Stevens)**	**Anchoring SW Process (USC)**	**PSSES (U. of Alabama)**	**SSEE (CMU/SEI)**	**Macro Risk Model/Tool**
	Concept Dev								
1	Atleast 2 alternatives have been evaluated	x			x	x	x (w.r.t NPR)	(x)	
2	Can an initial capability be achieved within the time that the key program leaders are expected to remain engaged in their current jobs (normally less than 5 years or so after Milestone B)? If this is not possible for a complex major development program, can critical subsystems, or at least a key subset of them, be demonstrated within that time frame?	x		(x)	x	x (5 years is not explicitly stated)		(x) (seems to be inferrable from the conclusions)	(x) (implies this)
3	Will risky new technology mature before B? Is there a risk mitigation plan?	x	x	x		(x)		x	x
4	Have external interface complexities been identified and minimized? Is there a plan to mitigate their risks?	x		x		x	x	x	x
	KPP and CONOPS								
5	At Milestone A, have the KPPs been identified in clear, comprehensive, concise terms that are understandable to the users of the system?	x	(x)	x	(x)	x (strongly implied)	(x) (implied)	x	x
6	At Milestone B, are the major system-level requirements (including all KPPs) defined sufficiently to provide a stable basis for the development through IOC?	x	x	(x)	x	x	(x)	(x) (There is no direct reference to this but is inferrable)	x
7	Has a CONOPS been developed showing that the system can be operated to handle the expected throughput and meet response time requirements?	x	x	(x)	(x)	x	(x) (there is a mention of a physical solution. That's the closest in this regard)	x	x
	Legend: **x = covered by EM** **(x) = partially covered (unless stated otherwise)**								

		NRC	Probability of Success	SE Leading Indicators	LIPSF (Stevens)	Anchoring SW Process (USC)	PSSES (U. of Alabama)	SSEE (CMU/SEI)	Macro Risk Model/Tool
	Cost and Schedule Scoping								
8	Are the major known cost and schedule drivers and risks explicitly identified, and is there a plan to track and reduce uncertainty?	x	x		(x)	x	(x) (seems to imply)	(x) (They aren't identified per se. It's only "questioned" as such.)	x
9	Has the cost confidence level been accepted by the stakeholders for the program?	x	x		x	x	(x)	x (not directly stated)	(x)
10	Is there a sufficient collection of models and an appropriate simulation environment to validate the selected concept and the CONOPS against the KPPs?	x	x			x	x	(x)	(x) (seems to be)
11	At Milestone B, do the requirements take into account likely future mission growth over the program life cycle?	x	x		(x)	(x)	(x)		x
	Architecture dev								
12	Has the system been partitioned to define segments that can be independently developed and tested to the greatest degree possible?	x				(x) (not directly stated as such)	x	x	
13	By Milestone A, is there a plan to have information exchange protocols established for the whole system and its segments by Milestone B?	x		(x) Seems far fetched though			(x)	x	
14	At Milestone B, has the government structured the program plan to ensure that the contractor addresses the decomposition of requirements to hardware and software elements sufficiently early in the development program?	x					(x) (nothing specific to the contractor though)	x	
	Risk Assessment								
15	Have the key risk drivers (not only the technology drivers) been identified?	x	x	x	(x) Indirect inkling	x	(x) (majorly technical)	x	x

		NRC	Probability of Success	SE Leading Indicators	LIPSF (Stevens)	Anchoring SW Process (USC)	PSSES (U. of Alabama)	SSEE (CMU/SEI)	Macro Risk Model/Tool
	Program Implementation Strategy								
16	Does the government have access over the life of the program to the talent required to manage the program? Does it have a strategy over the life of the program for using the best people available in the government, the FFRDCs, and the professional service industry?	x		(x)		(x)			x
17	At Milestone A, is there a plan defining how the pre-Milestone B activity will be done, and by whom?	x	(x)		x	x			(x)
18	Is there a top-level plan for how the total system will be integrated and tested?	x	x		(x)	x	x	x	x
19	At Milestone B, have sufficiently talented and experienced program and systems engineering managers been identified? Have they been empowered to tailor processes and to enforce requirements stability from Milestone B through IOC?	x	(x)	x		x	(x) (loosely connected)	(x)	x
20	Has the government attempted to align the duration of the program manager's assignment with key deliverables and milestones in the program?	x							
	Miscellaneous								
21	Status of Contractor's business and his team? Corporate (about the organization) and or program indicators (team set up and issues faced etc).		x		x				
22	Program fit in capability vision		x				(x)	(x)	
23	Staffing and manning status/planning		x	x				x	x
24	Process Compliance (or rationale of choice)	(x) (allows for process tailoring)		x		x	(x)	(x)	(x)
25	Review of review process	(x) (Sharing best practices with other agencies)		(x) Pretty close	x		(x)	x	(x)
26	Reuse claim validation	(x)			x	x			
27	Level of Service Validation					x			(x)

		NRC	Probability of Success	SE Leading Indicators	LIPSF (Stevens)	Anchoring SW Process (USC)	PSSES (U. of Alabama)	SSEE (CMU/SEI)	Macro Risk Model/Tool
28	COTS and third party solutions	x				x		x	x
29	Technical success/progress measurement		(x)	x			x	x	x
30	Verification/Validation and Configuration management	x (V&V seems implicit)						x	(x)
31	What phases of the SDLC would be included in developing the system	(x) (implied in process tailoring)						x	
32	Using Integrated Project Teams (IPT)							x	
33	Correlation with success on previous projects							x	
34	Frequency of change in requirements	(x) (Indirect reference in CM)				(x)		x	
35	About the contract (contract change orders received, %age subcontracted to suppliers, current/initial contract value of project)		x					x	
36	Stakeholder Identification					x		x	x
37	Questions about the product - Who is acquiring this product, end users, UI, environment of use/deployment etc.					(x)		x	(x)
38	Compliance with policy/standards/security etc							x	x
39	Requirements/Architecture Trace	(x)			x	x	x	x	(x)
40	Funding Stability				x			(x)	
41	Key reviews slip more than 30 days				x			x	
42	Program governance process, System Eng. Plan well articulated	(x)	x		x	x	x		
43	Process Improvement	x		(x) (mentioned as a part of process tailoring effort)		(x) (implied in process strategies)		x	
44	Work Breakdown structure			(x) (mentions about work products)				x	(x) (mention about incremental development of work products)
45	Earned Value Management		x	(x) (no direct mention)		(x) (talks about "adding value" and ROI)		x	

APPENDIX E: SEPRT-DAPS MAPPING

	Systems Engineering Effectiveness Measures F					DAPS Methodology v2.0			
						1 = Mission Capabilites; 2 = Resources; 3 = Management;			
						4 = Technical Process; 5 = Performance; 6 = Special Interest Areas			
								General Comment: To be truly complementary to the DAPS, the questions need to be put in perspective of the program life cycle. Are these questions focused on the contractor/supplier or the government acquisition team? It is often difficult to map because if it unclear what is appropriate when. Also need to look at terminology. Often, the terminology is too vague to understand what is really intended by the question.	
	SE EM Framework Area				***Interpretation***	***DAPS Section***	***DAPS Topic Covered***	***Comments/ Observations***	***References**** ****Not every reference is recorded here.***
4	**1**	**Concurrent definition of system requirements and solutions**							
5									
6		**1.1**		**Understanding of stakeholder needs: capabilities, operational concept, key performance parameters, enterprise fit (legacy)**		1.1	CONOPS		
7			1.1.1	At Milestone A, have the KPPs been identified in clear, comprehensive, concise terms that are understandable to the users of the system?	Understandable, comprehensive requirements	1.3.2	KPPs and KSAs	KPPs are required to be "established and documented"; no guidance on understandability/quality of KPP; however states-->	"1.3.2.Q7: After reviewing the table with the program's KPPs, including Net-Ready and Force Protection KPPs, can the PMO personnel explain the rationale for the thresholds and objectives?"
8			1.1.2	Has a CONOPS been developed showing that the system can be operated to handle both nominal and off-nominal workloads, and to meet response time requirements?	feasible workload demonstrated at CONOPS; are scenarios quantified	1.1 1.2 1.3.1	CONOPS Analysis of Alternatives Reasonableness, Stability, and Testability	DAPS specifies "realistic" scenarios, not necessarily "nominal and off-nominal workloads." These terms and "response time" are more network-oriented. Quantification is given by "measures of effectiveness."	"The material from a CONOPS will feed into many elements of information required by the Department of Defense (DoD), such as the JCIDS process, the Test and Evaluation (T&E) process, and the Analysis of Alternatives (AoA). 1.2.1.Q1: How were mission tasks (MTs), measures of effectiveness (MOEs), and measures of performance (MOPs) derived from relevant guidance on requirements or capabilities (e.g., Mission Needs Statement (MNS), Operational Requirements Document (ORD) (if pertinent), or the problem statement found in the ICD? [1.2.1.C1] •Are they quantifiable? [1.2.1.C1] 1.2.1.Q5: Are the threats and scenarios realistic and current? [1.2.1.C1] 1.3.1.Q5: How does the ICD describe the threats and the operational environment in which the capabilities are to be exercised? Were the threats and scenarios validated by the Defense Intelligence Agency (DIA)? [1.3.1.C1]

				SE EM Framework Area	Interpretation	DAPS Section	DAPS Topic Covered	Comments/ Observations	References* *Not every reference is recorded here.
10			1.1.3	Has the ability of the system to meet mission effectiveness goals been verified through the use of modeling and simulation?	verification of mission goals	1.2.1 1.3.1 4.4.2	Validity and Currency (1.2 Analysis of Alternatives) Reasonableness, Stability, and Testability Modeling and Simulation Tools		1.2.1.Q2: Are the MOEs stated in terms of military utility and based on value provided to the warfighter? •Are these MOEs used to identify models, simulations, and other analysis tools required to execute the study? [1.2.1.C1] 1.3.1.C12: Verification of all KPPs, MOEs, measures of suitability (MOSs), and Critical Technical Parameters (CTPs) are demonstrated by prototypes or engineering development models operating in the system's intended environment. Results are documented in test and evaluation reports described and documented in accordance with the Test and Evaluation Master Plan (TEMP). Deficiencies have been documented and analyzed, and the associated risks for successful testing are manageable. 4.4.2.C1: The program has a documented modeling and simulation (M&S) approach for design and analysis, which covers its purpose and use. All assumptions and weaknesses inherent in the program's M&S activities are made apparent to decision makers. This approach is cross-referenced in the Test and Evaluation Master Plan (TEMP) and Systems Engineering Plan (SEP).
11			1.1.4	Have the success-critical stakeholders been identified and their roles and responsibilities negotiated?	stakeholders identifed and roles defined	3.3.3	Management Structure and Communications	DAPS does not address the "negotiation" of roles and responsibilities. This term implies that the person performing the task has the option to choose not to perform some part of the task. In DAPS, the PMO is in charge and identifies what needs to be done and who shall address it.	3.3.3.C3: The PMO is organized to execute the SDD phase. Program IPTs or equivalent are formed and will include all appropriate program stakeholders to support SDD (ideally these IPTs are jointly formed with the contractor IPTs). The organization includes support from the acquisition organization infrastructure, agencies like DCMA, OSD, and from contracted support personnel, as required. The roles and responsibilities are clearly defined and consistent with achieving program objectives. 3.3.3.C5: The contractor development team is organized to execute the SDD phase. Program IPTs or equivalent are formed and include representatives from all appropriate stakeholders, including the PMO. The team includes support from the company infrastructure, subcontractors and contracted support personnel, as required. Roles, responsibilities, and lines of authority are clearly defined and consistent with achieving program objectives.
12			1.1.5.	Have questions about the fit of the system into the stakeholders' context -- acquirers, end users, administrators, interoperators, maintainers, etc. -- been adequately explored?	system fit in context; scenarios cover spectrum of occurrences once fielded	1.3 4.1.6	Capabilities: Perspective Sustainment as a Design Consideration		"For a materiel solution to a capability requirement, fielding an operational capability starts with sound strategies for requirements, acquisition, test and evaluation (T&E), and support and sustainment. To be viable, these strategies will be developed in concert and require early and ongoing collaboration among operators, developers, acquirers, testers, sustainers, and operations analysts. No one strategy can stand alone and still be viable because all are interdependent and require the integration of the others to be effective." "4.1.6.Q4: How is the program planning to include inputs from warfighters, users, developers, acquirers, technologists, testers, budgeters, and sustainers during capability needs development?"
13									
14		**1.2**		**Concurrent exploration of solution opportunities; analysis of alternatives (AoAs) for cost-effectiveness and risk (measures of effectiveness)**		1.2	Analysis of Alternatives		

	SE EM Framework Area				Interpretation	DAPS Section	DAPS Topic Covered	Comments/ Observations	References* *Not every reference is recorded here.
16			1.2.1	Have at least two alternative approaches been explored and evaluated?	alternative approaches	1.2	Analysis of Alternatives	Inferred, by definition of AoA	
17			1.2.2	At Milestone B, has the government structured the program plan to ensure that the contractor addresses the allocation of capabilities to hardware, software, and human elements sufficiently early in the development program?	allocation of capabilities to physical architecture	4.5.1	Software Development Plan		Pre-milestone B: 4.5.1.C8: Externally visible properties of the system, manifested in software and hardware, have resulted in requirements and architecture artifacts that have been carried forward from Milestone A and resulted in plans and technical data that are driving requirements refinement, design, and test development. 4.5.1.Q9: Walk through the architecture and design of the system as known now, and demonstrate alignment between program office and contractor views. Focus particularly on requirements development and traceability, identifying artifacts and processes that demonstrate ongoing alignment among the program office and contractor, as requirements evolve from externally visible (architecture) properties to internally visible (design) properties. [4.5.1.C8]
18			1.2.3	Has the claimed degree of reuse been validated?	Actual reuse, reuse validated	3.3.4 4.5.1	Management Methods, metrics, and Techniques Software Development Plan		3.3.4.3.C8: The Government Program Office should initially approve the program metrics and then periodically, e.g., monthly, the metrics should be reported and reviewed. These metrics should include many, if not all of the following: Development status S curves; Processor throughput utilization; Processor memory utilization; Input/output utilization; Software Engineering Staffing; Software Work Packages Summary; Schedule Performance Index; Cost performance Index; Problem/Deficiencies /Discrepancies Status; Requirements Stability; Software Size; Software Reuse Status (planned versus 'actuals'); Reliability Growth Curve; Logistics Footprint Reduction; Planned Operational Effectiveness; Product Availability Predictions; O&S Cost Projections; Development Test entrance criteria and status; DAES Reporting (For MDAPS); Milestone B and C entrance criteria. 4.5.1Q8: Does the Software Development Plan provide for early demonstrations (prior to the Preliminary Design Review (PDR)) of software reuse candidates on system simulations? [4.5.1.C7 Reuse of software, from existing systems or prior development efforts, has been analyzed for complexity and suitability to meet required functionality, in accordance with accepted software engineering standards.]
19			1.2.4	Have the claimed quality of service guarantees been validated?	validated system performance	4.4.2 5.1	Modeling & Simulation Tools Performance Effectiveness	DAPS does not use the term "quality of service"; assume it is the same as system performance parameters	4.4.2.C3: The program uses M&S during the Concept Refinement and Technology Development phases to: ...Identify and assess the system's performance in its intended operating environment – both physical (mechanical and electromagnetic) and operational (information exchange, threat, etc.) environments 5.1.1.C6: Sufficient CTPs are identified in the TEMP and measure critical system characteristics that, when achieved, allow the attainment of desired operational performance capabilities. With each technical parameter, thresholds are identified for each stage of development.

	SE EM Framework Area				Interpretation	DAPS Section	DAPS Topic Covered	Comments/ Observations	References* *Not every reference is recorded here.*
21			1.2.5	Have proposed COTS and third-party solutions been validated for maturity, compatibility, supportability, suitability, and effectiveness, throughout the expected system lifetime?	COTS maturity, suitability	1.2.1 5.4.1	Validity and Currency Assessed Manufacturing	Does not address COTS "validation" specifically, but does require a determination of suitabilty through an acceptance process.	1.2.1.Q9: Does the prioritized list resulting from the AMA address technological maturity, technological risk, supportability, and the affordability of each approach using the best available data in the pre-ICD process? [1.2.1.C2] 5.4.1.C12: Planned non-developmental items (NDI) or commercial-off-the-shelf (COTS) items have been determined to meet program system performance and sustainment requirements through a defined acceptance process. 5.4.1.Q12: What are the NDI or COTS items being used in the TD? • What are the sources of these items? • How have these items been determined to meet intended program performance requirements? [5.4.1.C12] 5.4.1.C24: Planned NDI and COTS items have been determined to meet program system performance and sustainment requirements through a defined acceptance process. 5.4.1.C43: Planned NDI or COTS items have been determined to meet program system performance and sustainment requirements through a defined acceptance process.
22									
23		**1.3**		**System scoping & requirements definition (external interfaces; memoranda of agreement)**		3.3.6	Management of Dependencies and External Interfaces (FoS / SoS)		3.3.6.C11: The boundary and scope of the SoS is understood by the PM and system engineers and the SoS is adaptable to boundary and scope changes over time. All systems included in the SoS should be identified. Interfaces from the SoS to external systems should be defined and scoped. Specific stakeholders of the SoS and its systems should be identified, including their organization. Identification of the users for each system is key.
24			1.3.1	Have external interface complexities been identified and minimized via MoAs or their equivalent? Is there a plan to mitigate their risks?	External interface agreements	3.3.1 3.3.6	Program Plan/Schedule Management of Dependencies and External Interfaces (FoS / SoS)		3.3.1.Q32: How does the program ensure that all key strategies and top-level plans remain consistent and aligned (i.e., coordinated) with the IMP/IMS? •Are the type and number of technical reviews correct in each appropriate plan? •Does the IMS capture both the government SEP and the prime contractor's SEMP/SEP activities, events, and milestones? • Are the scheduled interfaces w FoS/SoS correctly captured in the IMS, SEP, TEMP, and other related plans? •Did the plans adequately address or reference all key processes (e.g., Requirements, Risk Management, V&V, Monitoring & Control, Continuous process improvement, etc.)? [3.3.1.C5] 3.3.6.Q5: Does the SEP and TES address the interface interdependency plans for development and test. [3.3.6.C6] 3.3.6.Q14: How will FoS/SoS interfaces be managed? And what is the plan to resolve issues that cross PM, PEO, and Service lines? • Have Interface Control Documents been identified/developed and Interface Control Working Groups been assigned? • Provide a summary of the Memorandums of Agreement (MOAs) • Do the MOAs include any "triggers" that require a FoS/SoS member to inform the others if there is a cost, schedule, or performance deviation? 3.3.6.C11: The boundary and scope of the SoS is understood by the PM and system engineers and the SoS is adaptable to boundary and scope changes over time. All systems included in the SoS should be identified. Interfaces from the SoS to external systems should be defined and scoped. Specific stakeholders of the SoS and its systems should be identified, including their organization. Identification of the users for each system is key.

				SE EM Framework Area	Interpretation	DAPS Section	DAPS Topic Covered	Comments/ Observations	References* *Not every reference is recorded here.*
26			1.3.2	At Milestone B, are the major system-level requirements (including all KPPs) defined sufficiently to provide a stable basis for the development through IOC?	requirement definition level sufficient for development	4.2.1	Analysis and Decomposition (Pre Milestone B criteria)		4.2.1.C7: System requirements specifications and performance test/verification requirements are linked and verification methods are defined. Note: Allocation of system functions defines the functional baseline of the system design. • Traceability to current requirements documentation is configuration managed for approved capability upgrades commensurate with maturity of the technology required for the upgrade. Maturity is verified through readiness assessments and well-defined metrics. •The system architecture is well defined and documented, and is in accordance with all applicable standards, protocols and data interchange definitions as defined by key interface descriptions. •Test verification descriptions, critical to the process, are defined for each performance requirement. •Specifications are allocated and defined to the appropriate level consistent with the System Development and Demonstration (SDD) phase objectives. 4.2.1.C12: •Software requirements are evaluated to ensure that they are complete, unambiguous, correct, consistent, verifiable, modifiable, traceable, ranked for importance, and ranked for stability. Note: Compliance with IEEE Recommended Practice for Software
27			1.3.3	By Milestone A, is there a plan to have information exchange protocols established for the whole system and its segments by Milestone B?	Communication protocols	3.3.3	Management Structure and Communications (pre-Milestone A criteria) Management Structure and Communications (pre-Milestone B criteria)		3.3.3.C2: The PMO organization is structured to interface closely and openly with the contractor as well as other stakeholder organizations. The PMO leverages other government organizations to benefit the TD effort. 3.3.3.C6: The contractor program office communicates programmatic information internally and externally in a timely and accurate manner across the contract team including subcontractors. For large, geographically distributed system development, electronic database tools are used to support this communication. The participating groups and functions, including production and support functions, are tied into the communication channels and process.
28			1.3.4	Have the key stakeholders agreed on the system boundary and assumptions about its environment?	Stakeholder agreement on requirements	4.2.2 3.2.2 3.3.6 4.2.4`	Management of Requirements Entrance and Exit/Success Criteria Management of Dependencies and External Interfaces Trade Studies and Approaches	DAPS seems to give the mechanisms to do so, but does not always ask if agreement has been achieved; it seems to be assumed by the collaborative efforts.	4.2.2.Q8: Do the stakeholders understand and accept all the requirements? [4.2.2.C3] 3.2.2.C5: Exit/Success Criteria from CR phase – all reviews, technical and programmatic (i.e., ITR and ASR), in support of specific decision points have been successfully conducted with valid documentation, data and analyses. 3.2.2.Q21: As a result of the ASR, does the resulting set of requirements agree with the customer needs and expectations, and can the system under review proceed into the TD phase? [3.2.2.C5] 3.3.6.C12: In a SoS program, the technical planning process must be initiated top-down but iterated within individual systems until a consensus approach is agreed upon and resourced. Systems engineers from across the SoS must share data and plans and engage as part of a collaborative team for the SoS. It is important to recognize the value of a collaborative SE team and value of integration facilities, which promote open and active exchange and experimentation among members of the SoS SE team. 4.2.4.C2: The trade space (i.e., the set of program and system parameters, attributes, and characteristics required to satisfy performance standards) has been identified in general terms and agreed to by the stakeholders – the program manager (PM) and the capability needs approval authority.
29									

	SE EM Framework Area				Interpretation	DAPS Section	DAPS Topic Covered	Comments/ Observations	References* *Not every reference is recorded here.
31		**1.4**		**Prioritization of requirements & allocation to increments**		4.2.2	Management of Requirements	DAPS often mentions an incremental approach but really does not mention anything on how to divide the requirements into increments or to prioritize requirements. It seems to assume that all requirements will be implemented as planned.	4.2.2.C5: The program's systems engineering (SE) process during the Technology Development (TD) phase is disciplined in documenting and tracking specifications at all levels, and structured to manage changes. Integral to this process is configuration management (CM). The CM plan lays out the process and plans to ensure that designs are traceable to requirements, that change is controlled and documented, that interfaces are defined and understood, and that there is consistency between the product and its supporting documentation. 4.2.2.Q9: How does the requirements management plan address the validation of requirements? • How are the prioritized evaluation criteria consistent with requirements, and the operations and sustainment concepts? [4.2.2.C3]
32			1.4.1	Can an initial capability be achieved within the time that the key program leaders are expected to remain engaged in their current jobs (normally less than 5 years or so after Milestone B)? If this is not possible for a complex major development program, can critical subsystems, or at least a key subset of them, be demonstrated within that time frame?	schedule feasibility	3.1.1	Acquisition Strategy/Credibility	DAPS does not address the timeframe of personnel assignments, just feasibility within the program's schedule	3.1.1.Q1: How is the Acquisition Strategy realistic? • How are the program objectives attainable? • What is the strategic approach to attaining the program objectives? • Can this strategic approach be successfully implemented with reasonable certainty? Note: There is no simple formula for ensuring the approach is realistic. To evaluate it, reviewers must perform a detailed study of the threat, assess the state-of-the-art in all technology areas, review past performance on similar acquisitions or systems, and survey industry capability, then attain consensus on the complete analysis. Studies take time and resources, but because realism is such an important criterion for a successful strategy, every effort should be made to support this undertaking in critical areas [3.1.1.C1]
33			1.4.2	At Milestone B, do the requirements take into account likely future mission growth over the program life cycle?		4.2.1 4.2.2	Analysis and Decomposition Management of Requirements	Requires "flexibility" for change	4.2.1.Q21: What are the features of the design architecture that will ensure it remains robust and adaptable throughout the system life cycle? [4.2.1.C7] 4.2.2.C4: The evolutionary Acquisition Strategy (AS) utilizes a management system that continually defines the requirements and development activities to support the evolving needs; adequately addresses the various concerns of users, developers, and managers; and mitigates the risks associated with these issues are mitigated. The basic system architecture is designed to accommodate change. Techniques such as open systems design, functional partitioning and modular design have been addressed by the PM to achieve a flexible system that can be easily and affordably modified.

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35				1.4.3	Have appropriate early evaluation phases, such as competitive prototyping, been considered or executed for high-risk/low-maturity components of the system?	high-risk mitigation	2.1 3.3.1 4.1.1 4.3.1 4.3.3	Program Schedule Overview Program Plan/Schedule System Assurance Technical Review Planning (Pre Milestone B) Baseline Stability	Emphasis is on identifying the risks and does not say specificially how to handle the risks. "Prototypes are used as part of the SDD process, as are reviews, methods, and tools."	Perspective: Experienced program personnel provide data regarding critical and high-risk efforts and identify as realistically as possible the expected schedule, which the program management office then compares with the top-level defense program schedule template to determine the actual schedule risk and to identify all schedule drivers. With this approach, the probability of overrunning a program schedule can be estimated by determining how much risk exists and where it is greatest. This approach enables program managers (PMs) to estimate early and continuously in the program the possibility of a significant likelihood of overrunning the program schedule by determining how much and where the risk to successful schedule completion is greatest. "Early industry involvement is essential in the identification of the critical and high-risk efforts in the development of the integrated schedule. Integrated scheduling describes the detailed tasks that support the significant activities identified in integrated planning and timing of tasks." Identifies highest risk path and ensures PM is applying resources on it. 3.3.1.Q21: How are programs with high risk shown in the IMS in order to give the visibility to manage and control risk? [3.3.1.C2a] 4.1.1.C3: Pending the next version of DoDI 5000.2, "3.5.2.6. A list of known or probable Critical Program Information (CPI) and potential countermeasures such as Anti-Tamper (AT) in the preferred system concept and in the critical technologies and competitive prototypes to inform program protection (DoDD 5200.39, Reference (ai)) and design integration during in the TD phase." "The use of competitive prototyping is required by the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (OUSD(AT&L)) policy through the Technology Development phase up to Milestone B, which will include the Preliminary Design Review." 4.3.1.C13: The SRR is typically held well in advance of Milestone B to allow time for issue resolution and proper executive level concurrence on process and results. 4.3.3.C3: The functional baseline should be established at the System Functional Review (SFR) during the Technology Development phase. Competitive prototypes of system or subsystem components should be developed and tested to ensure program requirements are achievable.
36				1.4.4	Have stakeholders agreed on prioritization of system features and their allocation to development increments?	Prioritization of capabilities/ requirements	4.5.1 4.2.1	Software Development Plan (Requirements) Analysis and Decomposition	Ranking of requirements is only mentioned in the Software Development section.	4.5.1.Q4: Walk through the architecture of the system as known now, and demonstrate alignment between program office and contractor views. Focus on requirements traceability, from initial specification of capabilities to high-level requirements and preliminary architecture. [4.5.1.C3] 4.5.1.Q9: Walk through the architecture and design of the system as known now, and demonstrate alignment between program office and contractor views. Focus particularly on requirements development and traceability, identifying artifacts and processes that demonstrate ongoing alignment among the program office and contractor, as requirements evolve from externally visible (architecture) properties to internally visible (design) properties. [4.5.1.C8] 4.5.1.C11: Software process integration has facilitated timely and efficient program integration. Information flow has not been impeded, and risks traceable to information flow have been perceived and mitigated in a timely fashion. There has been agreement on software metrics and plans between the program office and contractor. 4.2.1.C12: •Software requirements are evaluated to ensure that they are complete, unambiguous, correct, consistent, verifiable, modifiable, traceable, **ranked for importance,** and ranked for stability.
37										

				SE EM Framework Area	Interpretation	DAPS Section	DAPS Topic Covered	Comments/ Observations	References* *Not every reference is recorded here.*
39	**2**			**System life-cycle organization, planning, an**		3.3.1	Program Plan/Schedule		
40									
41		**2.1**		**Establishment of stakeholder life-cycle responsibilities, authorities, and accountabilities (RAAs) (for system definition & system development)**		2.2.2 3.2.2 3.3.1 3.3.3	Continuity and Stability Knowledge-based Decisions and Milestones (Entrance and Exit/Success Criteria) Program Plan/Schedule Management Structure and Communications		2.2.2.Q3: How are the total life cycle support requirements and responsibilities addressed in the Logistics Support Plan? What are the bases for the estimates? [2.2.2.C1] 3.2.2.Q30: In preparation for the IBR, were the following documents provided by the contractor to the government for review? • Work Authorization Documents (WADs) • Responsibility Assignment Matrix (RAM) 3.3.1.Q33: How is the SEP updated and used by the Technical Leads and PM to manage the technical aspects/efforts of the program? •Was the SEP prepared in time to support RFPs? •Was the SEP updated after contract award to document the major events, revisions, slips in the schedule, technology immaturity, etc. that have occurred? Note: The SEP is the PM's overarching technical management tool that reflects both government and contractor activities, roles, and responsibilities. It is a living dynamic plan, updated as necessary [3.3.1.C5] 3.3.3.C5: The contractor development team is organized to execute the SDD phase. Program IPTs or equivalent are formed and include representatives from all appropriate stakeholders, including the PMO. The team includes support from the company infrastructure, subcontractors and contracted support personnel, as required. Roles, responsibilities, and lines of authority are clearly defined and consistent with achieving program objectives. 3.3.3.Q9: How are the various IPTs organized on the program, and do they have responsibility, experienced staff, and authority to make decisions?
42			2.1.1	Are the stakeholders who have been identified as critical to the success of the project represented by highly qualified personnel -- those who are collaborative, representative, authorized, committed, and knowledgeable?	Qualified staff	2.3.1	Sufficiency of Numbers and Qualifications	DAPS addresses the issue of quality staff in general, but does not differentiate with critical areas; also does not define what qualified people are.	2.3.1.C1: There is an established program/process in the program management office (PMO) that provides the right number and mix of qualified personnel to successfully execute the Technology Development (TD) phase. There is sufficient flexibility in the program to address program shortfalls through the use of Systems Engineering Technical Assistance (SETA) contractor personnel. 2.3.1.C2: The contractor has an established program that provides the right number and mix of qualified personnel to successfully execute the TD phase. Key contractor management and technical personnel, including the program manager, chief systems engineer, software architect, and functional area managers, have worked successfully on projects of similar complexity and have had significant work experience relevant to the current program phase.

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44			2. 1. 2	At Milestone A, are there validated plans, budgets, and schedules defining how the pre-Milestone B activity will be done, and by whom?	Validated plans	3.3.1	Program Plan/Schedule	How is a plan "validated"?	3.3.1.C1: The Integrated Master Plan (IMP) is an event-driven plan that documents the significant accomplishments necessary to complete the work and ties each accomplishment to a key program event that forms the foundation of the Integrated Master schedule (IMS). Note: The IMP Events are not tied to calendar dates; each event is completed when its supporting Accomplishments are completed and as evidenced by the Criteria completion supporting each of those Accomplishments. •Was the SEP updated after contract award to document the major events, revisions, slips in the schedule, technology immaturity, etc. that have occurred? Note: The SEP is the PM's overarching technical management tool that reflects both government and contractor activities, roles, and responsibilities. It is a living dynamic plan, updated as necessary [3.3.1.C5] 3.3.1.C6: During program planning, the government created a top level program schedule or Roadmap which provides a capstone program summary allowing insight into the government's program planning and approval process. This initial Roadmap, along with other program documentation, provides the basis for an initial set of expectations for the program with the warfi •Is prepared by the government program office early in the program planning phase in conjunction with any other supporting or associated government program offices • Is focused on and conveys the "big picture" of the program objectives, capabilities evolution, summary schedule, and any major program constraints •Supports initial and subsequent budget submissions and provides the basis for developing a sound position on funding cuts or increases throughout the program life •Contains key events and shows critical schedule interfaces (e.g., IOC and FOC) with all supporting programs and activities (for example, other Services, DARPA, and other agencies) and their supporting contracts •Is reviewed regularly by the primary program team and supporting program teams to assess progress toward accomplishing key event and schedule interfaces •Helps detect disconnects early, and thus provide sufficient lead-time and a planning tool to help address them •Is able to be traced to the major events of the proposal and, upon contract award, trace to the IMP/IMS •Is kept current
45			2. 1. 3	Has the government attempted to align the duration of the program manager's assignment with key deliverables and milestones in the program?	Assignment duration			DAPS does not address the timeframe of personnel assignments, just feasibility within the program's schedule	

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47			2.1.4	Have the key stakeholders agreed to the proposed assignments of system roles, responsibilities, and authorities?	Roles and responsibilities	3.3.6 3.4.2 4.1.6 4.3.1	Management of Dependencies and External Interfaces Subcontractor management Sustainment as a Design Consideration Technical Review Planning		3.3.6.C12: In a SoS program, the technical planning process must be initiated top-down but iterated within individual systems until a consensus approach is agreed upon and resourced. 3.4.2.Q9: How has the PM addressed intra-government work agreements, i.e., formal agreements, project orders, or work requests, in which one government activity agrees to perform work for another, creating a supplier/customer relationship? 3.4.2.Q24: How have teaming agreements been documented, defined, and communicated among all relevant parties? •What is the process for making changes to agreements, and who is involved? [3.4.2.C1a] 4.1.6.C15: The PM shall work with the users to document performance and support requirements in performance agreements specifying objective outcomes, measures, resource commitments, and stakeholder responsibilities. The military Services shall document sustainment procedures that ensure integrated combat support. 4.3.1.C30: The IBR establishes a mutual understanding of the Performance Measurement Baseline (PMB) and provides for an agreement on a plan of action to evaluate risks inherent in the PMB and
48									
49		**2.2**		**Establishment of integrated product team (IPT) RAAs, cross-IPT coordination needs**		3.1.1 3.3	Acquisition Strategy/Credibility Program and Project Management		•Use of Integrated Product Teams. When properly oriented and challenged, the multifunctional members of the IPT become committed to program success, thereby reducing parochial or functional imbalances that could otherwise lead to future instability. [3.1.1.C1] Integrated product and process development is a management process that integrates all activities from the concept of a new defense system through the entire life cycle, using multidisciplinary teams, called Integrated Product Teams (IPTs). "The DoD has recognized the importance of integrated product teams as a means to aid the program manager, and as a way to streamline the decision process. By working as part of cross-functional teams, issues can be identified and resolved more quickly, and stakeholder involvement in the overall success of the program can be maximized. In this way the program manager capitalizes on the strengths of all the stakeholders in the defense acquisition system."
50			2.2.1	Does the project make effective use of Integrated Project Teams (IPTs) throughout the supplier hierarchy?	Use of IPTs	3.3.3	Management Structure and Communications		3.3.3.C1: The PMO is organized to execute all functions in preparation for Milestone A review and TD activities, including the plan for formation of appropriate Integrated Product Teams (IPTs) or their equivalents. Roles and responsibilities are clearly defined and consistent with achieving the TD objectives.
51			2.2.2	Are the IPTs staffed by highly qualified personnel, as in 2.a(a)?	Qualified staff	2.3.1	Sufficiency of Numbers and Qualifications	Addresses the issue of quality staff in general, but does not differentiate with critical areas or IPTs	2.3.1.C1: There is an established program/process in the program management office (PMO) that provides the right number and mix of qualified personnel to successfully execute the Technology Development (TD) phase. There is sufficient flexibility in the program to address program shortfalls through the use of Systems Engineering Technical Assistance (SETA) contractor personnel. 2.3.1.C2: The contractor has an established program that provides the right number and mix of qualified personnel to successfully execute the TD phase. Key contractor management and technical personnel, including the program manager, chief systems engineer, software architect, and functional area managers, have worked successfully on projects of similar complexity and have had significant work experience relevant to the current program phase.

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53			2.2.3	For IPTs addressing strongly coupled objectives, are there "super-IPTs" for resolving conflicts among the objectives?	Strongly coupled	 3.2.1 1.1 4.1.2	Introduction Statutory and Regulatory Compliance and Guidance Concept of Operations Modular Open Systems Approach	DAPS has an Overarching Integrated Product Team but it is unclear on this group's purpose or participation in the program during all life cycles. DAPS mentions planning for resolving issues throughout, but does not mention "super IPTs" per se. DAPS also recommends MOSA as an approach to resolve capability coupling	"Quick-look" reviews are conducted 2 to 3 months before the milestone, using the same form and formats as a full assessment. They are conducted as a "for record" review to support the Defense Acquisition Board's (DAB) Integrated Process/Product Teams (IPTs), Overarching Integrated Product Teams (OIPTs), or if requested, for the DAB." 3.2.1.Q5: What are the Service-specific regulatory requirements for the program? • Are they in conflict with higher level (e.g., DoD) regulations? • What are the impacts of any conflict to the program? •How have these conflicts been resolved? If not, were the conflicts addressed at the OIPT"Developing the CONOPS as a team effort helps resolve requirement debates and facilitates completeness of requirements." 4.1.2.C2: To realize open systems benefits, programs need to continually measure their progress toward achieving MOSA-enabled capabilities/objectives. Percentage of key interfaces defined by open standards, or percentage of components/subsystems modularized (self-contained, decoupled, and encapsulated) are examples of open systems-related metrics.
54									
55		**2.3**		**Establishment of necessary resources for meeting objectives**		3.3	Program and Project Management		

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57			2.3.1	Have decisions about the use of one-shot, incremental, or evolutionary development been validated for appropriateness and feasibility, and accepted by the key stakeholders?	Incremental development	3.3 3.3.1	Program and Project Management Program Plan/Schedule	In general, DAPS uses the focus of working together. This probably implies "acceptance" but is not explicitly stated.	"Program management . . . represents the integration of a complex system of differing but related functional disciplines . . . that must work together to achieve program goals." 3.3.1.C6: During program planning, the government created a top level program schedule or Roadmap which . . . • Is focused on and conveys the "big picture" of the program objectives, **capabilities evolution**, summary schedule, and any major program constraints 3.3.1.Q36: How does the Government Roadmap Schedule capture the plan for executing the evolutionary acquisition (EA) strategy, with either a spiral or incremental development process? 3.1.1.C1: The program manager (PM) is developing a credible Acquisition Strategy that will provide the basis for meeting program objectives and therefore will be an aid in gaining program acceptance and support. The **credibility of the Acquisition Strategy is evaluated on five attributes**: • Realism • Stability • Resource balance • Flexibility • Managed risk 3.1.1.Q22: How does the Acquisition Strategy identify and describe the approach the program will use to achieve full capability: an evolutionary approach or a single-step approach? •What is the rationale for choosing the approach? •If an evolutionary approach is being used, how is Block I (the initial deployment capability) described; how will it be funded, developed, tested, produced, and supported; and what is the approach to treatment of subsequent blocks?

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59				2.3.2	Have system definition, development, test, and evolution plans, budgets, and schedules been validated for appropriateness and feasibility, and accepted by the key stakeholders?	system plans feasibility	3.1.1	Acquisition Strategy/Credibility	What is meant by "validated"? In general, DAPS uses the focus of working together. This probably implies "acceptance" but is not explicitly stated.	Before all milestones: 3.1.1.C2: The Acquisition Strategy is credible, based on the following five attributes: realism, stability, resource balance, flexibility, and risk management. The Acquisition Strategy provides the basis for meeting program objectives, thereby acting as an aid in gaining program acceptance and support. 3.1.1.C3: The Acquisition Strategy documents the ground rules and assumptions under which the program was started and upon which future decisions will be gauged. It becomes more definitive over the execution of the program in describing the relationships of the following essential elements: •Requirements •Structure and Schedule •Acquisition Approach •Risk Management •Program Management -Philosophy/Approach -Program Resources -Information Sharing and DoD Oversight -Integrated Digital Environment (IDE) -Defense Contract Management Agency (DCMA) Support -Government Property in the Possession of Contractors (GPPC) -Streamlining/Innovative Acquisition -Simulation-Based Acquisition (SBA) -Software-Intensive Programs •Design Considerations -Technology Transition •Support Strategy •Business Strategy Competition
60				2.3.3	Is there a valid business case for the system, relating the life cycle system benefits to the system total cost of ownership?	Business case	1.1.1 1.2 3.4.3	Mission Description Analysis of Alternatives Value Engineering		1.1.1.C1: The system's mission description clearly identifies mission need, objectives, and general capabilities. Included is a suitable description of the operational (including threat) and logistical environments envisioned for the system. Information is current. 1.2.1.C1: There is a viable Analysis of Alternatives (AoA) study plan that defines what will be accomplished and how it will be done. Minimum information in the study plan will include: background, purpose, scope, acquisition issues, alternatives, effectiveness and cost methodologies, analytical tools, and schedule to complete the AoA. 1.2.1.C2: The Analysis of Materiel Approaches (AMA), if conducted, provides the best materiel approach or combination of approaches to provide the desired capability or capabilities. The AMA determines the best way(s) to use materiel approaches to provide a joint capability. Note: Generally, the AMA will not consider which specific "systems" or "system components" are best. 3.4.3.C2: There is a viable Value Engineering system plan, within the goals and stipulations of the PMO's VE program, to effectively guide the successful development of solutions that eliminate or modify any element of the program that significantly contributes to the overall cost without adding commensurate value to overall system performance or program execution.
61										

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63		**2.4**		**Establishment of appropriate source selection, contracting, and incentive structures**		3.4 3.1	Contracting Acquisition Strategy (Credibility)		Figure 3-3 Contracting Management Process 3.1.1.Q60: What contract type(s) are identified in the Acquisition Strategy? • Explain why the contract types are suitable, including considerations of risk assessment and reasonable risk sharing by the government and the contractor(s). • How does the strategy explain the planned contract incentive structure, and how will the contract provide incentives for the contractor(s) to provide the contracted product or services at or below the established cost objectives? -If more than one incentive is planned for a contract, what is the explanation of how the incentives complement each other and do not interfere with one another? [3.1.1.C3]
64			2.4.1	Has the competitive prototyping option been addressed, and the decision accepted by key stakeholders?	competitive prototyping	4.1.1 4.3.1	System Assurance Technical Review Planning	Competitive prototyping is required, but it is unclear what needs to be done for it.	4.1.1.C3: Pending the next version of DoDI 5000.2, "3.5.2.6. A list of known or probable Critical Program Information (CPI) and potential countermeasures such as Anti-Tamper (AT) in the preferred system concept and in the critical technologies and competitive prototypes to inform program protection (DoDD 5200.39, Reference (ai)) and design integration during in the TD phase." Pre-Milestone B (New DoDI 5000.02) The use of competitive prototyping is required by the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (OUSD(AT&L)) policy through the Technology Development phase up to Milestone B, which will include the Preliminary Design Review. 4.3.1.Q20: How did competitive prototyping affect the SRR? How did prototype technical performance results help to mature the system requirements? Provide some examples. [4.3.1.C13]
65			2.4.2	If doing competitive prototyping, have adequate plans and preparations been made for exercising and evaluating the prototypes, and for sustaining core competitive teams during evaluation and down selection?	competitive prototyping plans	4.3.1	Technical Review Planning	How to plan for/use competitive prototyping in a contract or program management perspective is not really addressed. However, the results of competitive prototyping are used/evaluated at the major reviews.	Not addressed to this level; however it addressed in many areas. 4.3.1.C13: The SRR is typically held well in advance of Milestone B to allow time for issue resolution and proper executive level concurrence on process and results. Technical performance results from competitive prototyping should factor into the trade space for system requirements. 4.3.1.C21: The TD effort should mature the prototype technologies to an acceptable level of risk to proceed to EMDD and assessment by the SRR. The results of the TD effort should be reflected

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67			2.4.3	Is the status of the contractor's business and team "healthy," both in terms of business indicators, and within the industrial base for the program area? Is the program aligned with the core business of the unit, and staffed adequately and appropriately?	contractor qualifications	3.4	Contracting	The wording of this item is confusing. It seems to combine many issues into one. How is "healthy" defined/determined? What does "within the industrial base for the program area" mean? Does this mean financial stability of the company, ability to keep qualified staff, and whether this program is totally different from the company's usual business?	DAPS coveres whether a contractor is qualified in many areas, for example, 3.4.1.Q16: In regard to sources, to what extent has the acquisition team accomplished the following contracting functions: •Availability of qualified sources? • Determination if the source can meet the need? •For commercial sources, review of acquisition histories, conduct of market research, and preparation of source lists of identified sources? •Verification that a Qualified Bidders List, Qualified Manufacturers List, or Qualified Parts List (QBL/QML/QPL) applies to the procurement? •Determination from market research whether unlisted firms or products may be able to meet the minimum functional need? [3.4.1.C2b]3.4.1.Q56: 3.4.1.Q56: To what extent were past performance, technical and non-price factors addressed applied by the acquisition team? •How was the latest performance information in the Service's contractor performance assessment reporting system used? 3.4.2.C1a: The PMO and contractor have adequately addressed pre-award activities during the preparation of the solicitation. - Analysis of the Industrial Base – PM has determined the capabilities of the national technology a 3.4.2.Q5: What are the results of the PM's analysis of product and technology areas critical to meeting program needs? •How does the Acquisition Strategy identify the potential industry sources to supply these needs? •Does the prime contractor plan to provide critical product and technology areas internally, by subcontractor, or through exclusive teaming? 3.4.2.Q31: What is the status of subcontractor and supplier management planning? • How are audits, supplier ratings, metrics, value stream, etc., addressed in the planning? [3.4.2.C1c] • 3.4.2.Q32: How is the past performance of the prime contractors' management of subcontracts? What is the prime contractor's technical capability to manage the planned subcontractors? [3.4.2.C1c]

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69				2.4.4	Has the acquiring organization successfully completed projects similar to this one in the past?	Acquisitioner's experience	2.3	Introduction Staffing Level		Program Support Team Structure: The Program Support Team PST is composed of a team leader from SSE/AS and core subject matter expert members from OSD staff (AT&L, CAIG, DPAP, Networks and Information Integration (NII), and Director, Operational Test and Evaluation (DOT&E)). Additional subject matter experts may be recruited from the Services, DoD agencies, Federally Funded Research and Development Centers (FFRDCs), and academia based on specific assessment needs matched with individual expertise. -"The key to applying the assessment process successfully is to select a highly qualified, experienced team leader, and populate the team with experienced senior individuals. Collectively, the assessment team should bring expertise, experience, and knowledge in all areas that the assessment will address." 2.3: Perspective: Staffing is key to the ability of any PMO to execute its responsibilities. Composed of civilian, military, matrix support, and Systems Engineering Technical Assistance (SETA) (aka onsite support contractors), the staff is professional, agile, and motivated. It consistently makes smart business decisions, acts in an ethical manner, and delivers timely and affordable capabilities to the warfighter. A successful staff is more than luck; it is having the "right person" in a position, rather than simply filling a position. The program manager (PM) facilitates this success through improved recruitment, selection, and training. 2.3.1.Q4: What is the experience level of each of the existing or planned key technical personnel? How is the experience of technical personnel relevant to the current activity? [2.3.1.C1]
70				2.4.5	Has the candidate performing organization successfully completed projects similar to this one in the past?	contractor qualifications/ experience	2.3.1	Sufficiency of Numbers and Qualifications		2.3.1.C4: The contractor has an established program that provides the right number and mix of qualified personnel to successfully execute the SDD phase. Key contractor management and technical personnel, including the program manager, chief systems engineer, software architect, and functional area managers, have worked successfully on projects of similar complexity and have had significant work experience relevant to the current program phase. The contractor's policy and actual practice on workforce assignments reflect a commitment to a stable workforce throughout the SDD phase.
71				2.4.6	Is the program governance process, and in particular the system engineering plan, well articulated and compatible with the goals of the program?		3.3.1	Program Plan/Schedule	The term "Program governance process" is confusing--not sure how this relates to the system engineering plan.	Systems Engineering Plan (SEP) – The IMP and IMS supports the sound technical approach documented in the SEP. The IMP demonstrates the contractual commitment to the elements of major technical reviews and their entry and exit (success) criteria. The SEP and IMS demonstrate that Cost, Schedule and Performance are inter-related within the program. Note: Because the basic tasks within the IMS track the systematic flow of the engineering process, there should be a relationship between the SEP and the IMS. These processes, tools, and documents should be understood, linked, and tailored for an individual program's execution needs and management reporting requirements 3.3.1.Q32: How does the program ensure that all key strategies and top-level plans remain consistent and aligned (i.e., coordinated) with the IMP/IMS? •Are the type and number of technical reviews correct in each appropriate plan? •Does the IMS capture both the government SEP and the prime contractor's SEMP/SEP activities, events, and milestones? • Are the scheduled interfaces w FoS/SoS correctly captured in the IMS, SEP, TEMP, and other related plans? •Did the plans adequately address or reference all key processes (e.g., Requirements, Risk Management, V&V, Monitoring & Control, Continuous process improvement, etc.)? [3.3.1.C5]

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74		**2.5**		**Establishment of necessary personnel competencies**		2.3.1 2.2.1	Sufficiency of Numbers and Qualifications Program Funding and Allocation		Have the appropriate technical and programmatic competencies been involved in the CARD-like document development, and have the proper subject matter experts been involved in its review? (CARD-Cost Analysis Requirements Description
75			2.5.1	Does the government have access over the life of the program to the talent required to manage the program? Does it have a strategy over the life of the program for using the best people available in the government, the FFRDCs, and the professional service industry?	qualified Government staff	2.3.1	Sufficiency of Numbers and Qualifications		2.3.1.C1: There is an established program/process in the program management office (PMO) that provides the right number and mix of qualified personnel to successfully execute the Technology Development (TD) phase. There is sufficient flexibility in the program to address program shortfalls through the use of Systems Engineering Technical Assistance (SETA) contractor personnel. 2.3.1.Q6: Are the personnel (e.g., program management, contracting, oversight) trained to the appropriate levels in accordance with their acquisition career assignments? • Are government PMO personnel in acquisition-critical positions trained to the appropriate certification levels in accordance with their acquisition career assignments? [2.3.1.C1]
76			2.5.2	At Milestone B, have sufficiently talented and experienced program and systems engineering managers been identified? Have they been empowered to tailor processes and to enforce development stability from Milestone B through IOC?	qualified program management, system engineering; empowered staff	2.3.1 3.3.6	Sufficiency of Numbers and Qualifications (pre-milestone B) Management of Dependencies and External Interfaces	The two questions should be separated. Empowerment is different from qualified persons.	2.3.1.C3: The PMO staff is the right mix of qualified personnel to successfully execute the System Development and Demonstration (SDD) phase. Workforce management and training programs receive the highest priority in resources to ensure a qualified workforce to complete the SDD phase and transition to production. There is sufficient flexibility in the program to address program shortfalls through the use of SETA contractor personnel. Policies and standards are in place to ensure the thorough and continual training of the workforce and to evaluate worker performance. 2.3.1.C4: The contractor has an established program that provides the right number and mix of qualified personnel to successfully execute the SDD phase. Key contractor management and technical personnel, including the program manager, chief systems engineer, software architect, and functional area managers, have worked successfully on projects of similar complexity and have had significant work experience relevant to the current program phase. The contractor's policy and actual practice on workforce assignments reflect a commitment to a stable workforce t 3.3.6.Q11: • Is the SE&I lead empowered to integrate the programs within the SoS, and reallocate resources (e.g. funding and manpower) within the SoS from the "fast movers" to the "slow movers" program to keep the establishment of the SoS capability on track?
77			2.5.3	Has the government attempted to align the duration of the program manager's assignment with key deliverables and milestones in the program?				Length of assignment is not addressed in DAPS other than indirectly by "realism" guidelines	Length of assignment is not addressed
78			2.5.4	Is the quantity of systems engineering personnel assigned, their skill and seniority mix, and the time phasing of their application throughout the program life cycle appropriate?		2.3.1	Sufficiency of Numbers and Qualifications (pre-milestone B)		2.3.1.Q14: How has the contractor committed to having a quality workforce throughout the TD phase? [2.3.1.C2] Also, see above.
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	SE EM Framework Area				Interpretation	DAPS Section	DAPS Topic Covered	Comments/ Observations	References* *Not every reference is recorded here.
81	**3 Technology maturing, architecting**								
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83		**3.1**		**COTS/NDI evaluation, selection, validation for maturity & compatibility**		3.1.1	Acquisition Strategy		
84			3.1.1	Have COTS/NDI/Services opportunities been evaluated prior to baselining requirements?	COTS/NDI evaluation	3.1.1	Acquisition Strategy (Credibility)		3.1.1.Q52: How does the Acquisition Strategy consider both commercial and NDI sources as the primary source of supply? What is the role of market research in determining the availability and suitability of commercial and NDIs, and to what extent do the interfaces for these items have broad market acceptance, standards-organization support, and stability? •What is the role of commercial off-the-shelf (COTS) and NDI sources of supply to provide for the most cost-effective system throughout the system's life cycle? • How does the PM work with the user to define and modify, as necessary, requirements to facilitate the use of COTS items and NDIs? [3.1.1.C3]
85			3.1.2	Have COTS/NDI/Services scalability, compatibility, quality of service, and life cycle support risks been thoroughly addressed?		3.1.1	Acquisition Strategy (Credibility)	Suitability is addressed which should include these items, but all of them are not called out separately.	
86			3.1.3	Has a COTS/NDI/Services life cycle refresh strategy been developed and validated?	COTS refresh	3.1.2	Acquisition Strategy (Acceptability)		3.1.2.C1: Before development of a program Acquisition Strategy in the Technology Development (TD) phase, a Technology Development Strategy (TDS) is formulated during the Concept Refinement (CR) phase and approved by the MDA at Milestone A. The TDS contains the research and development strategy to be implemented—particularly in the TD phase—and the rationale for the planned acquisition approach to achieve full capability. 3.1.2.Q12: How is technology obsolescence factored into the TDS? • Does the strategy include a process to determine when technology-refresh actions should be performed? If not, why not? [3.1.2.C1] 3.1.2.Q29: How does the Acquisition Strategy describe the program's approach for applying Modular Open Systems Approach (MOSA), as characterized by the following attributes? ...•Commercial-off-the-shelf (COTS) technology refreshment plans
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88		**3.2**		**Life-cycle architecture definition & validation**		4.1.3	Architecture		

	SE EM Framework Area				Interpretation	DAPS Section	DAPS Topic Covered	Comments/ Observations	References* *Not every reference is recorded here.*
90			3.2.1	Has the system been partitioned to define segments that can be independently developed and tested to the greatest degree possible?	system partitioning	4.2.1	Analysis and Decomposition	The wording of this question is more software-oriented; the DAPS is more system-oriented	4.2.1.C4: The program manager (PM) or contractor has an effective systems engineering (SE) process in place to perform functional analysis and the allocation of functional requirements for the TD phase. This includes the traceability and verification of requirements across the entire system. • The SE process is effective in defining system requirements, functionality, and allocated physical architecture. •Technology maturity requirements are appropriately scoped for demonstration during the TD phase. •Analyses provide a clear, detailed description of the technical approach resulting from functional analysis and allocation. • The SE process uses rigorous and disciplined definitions of interfaces, and defines the key interfaces that require test verification within the system. • The SE process partitions the system into self-contained, groupings of interchangeable and adaptable modules. The process enables identification of key test and evaluation (T&E) requirements to verify sub-assembly performance during the TD phase.
91			3.2.2	By Milestone A, is there a plan to have internal and external information exchange protocols established for the whole system and its segments by Milestone B?	information exchange	1.3.2 4.2.1	Key Performance parameters and Key System Attributes Analysis and Decomposition		Pre milestone B: 1.3.2.C8: Programs will use standardized architectural products and conventions, data formats, and open interface standards and protocols to enable interoperability. Pre milestone A: 4.2.1.C1:• The system architecture is well defined and documented, and is in accordance with all applicable standards, protocols and data interchange definitions as defined by key interface descriptions.
92			3.2.3	Does the project have adequate processes in place to define the verification, test & validation, and acceptance of systems and system elements at all phases of definition and development?		4.6.1	Test and Evaluation Plan		4.6.1.C1: The program manager (PM) shall develop a robust integrated Test and Evaluation Strategy (TES) for all phases of the program, describing developmental test and evaluation (DT&E), operational test and evaluation (OT&E), and live-fire test and evaluation (LFT&E). Without compromising rigor, the program is required to integrate modeling and simulation (M&S) activities into the strategy. The TES should be consistent with and complementary to the Systems Engineering Plan (SEP).
93			3.2.4	Is there a clear, consistent, and traceable relationship between system requirements and architectural elements? Have potential off-nominal architecture-breakers been addressed?		1.3.1 4.1.3 4.2.1	Capatilities-Reasonableness, Stability, and Testability Design Considerations/Architecture Analysis and Decomposition	In DAPS, it is not explicitly required to have traceability between reqs and architecture	1.3.1.C10: Compatibility with other interfacing systems is maintained and verified through system-level testing as defined in interface specifications, through the development/design process, and is traceable to the architecture of the system. Interface specifications are under formal configuration control. 4.1.3.Q3: How is a change within the technical system descriptions ensured for traceability of impact across the system? [4.1.3.C3] 4.2.1.C4: The program manager (PM) or contractor has an effective systems engineering (SE) process in place to perform functional analysis and the allocation of functional requirements for the TD phase. This includes the traceability and verification of requirements across the entire system. • The SE process is effective in defining system requirements, functionality, and allocated physical architecture. 4.2.1.C10: The PM or contractor has an effective SE process in place to perform functional analysis and the allocation of functional requirements for the SDD phase. This includes the traceability and verification of requirements across the entire system. •The SE process is effective in defining system requirements, functionality, and allocated physical architecture.

				SE EM Framework Area	Interpretation	DAPS Section	DAPS Topic Covered	Comments/ Observations	References* *Not every reference is recorded here.
95			3.2.5	Does the architecture adequately reconcile functional hardware "part-of" hierarchies with layered software "served-by" hierarchies?	Architecture decomposition	4.1.3	Architecture	Unclear of the terminology used in this question	DAPS not written this way--think the following covers it: 4.1.3.C1: The system architecture and subsystem architecture, including computer system and support architectures, is defined using standardized methods, such as the Department of Defense Architecture Framework (DoDAF), and widely accepted tools sets, such as those that employ the Unified Modeling Language (UML), which meets the system requirements, including open-system requirements and benefits. Ease of change, growth, upgrade, and lifecycle support is facilitated with this architecture. 4.1.3.C2: The technical system architecture descriptions should use mandated Operational View (OV), System View (SV), and Technical View (TV) products as described in the DoDAF, and should be integral to the system design. There should be System Description Documents (SDDs) and System Capability Specifications (SCSs) that address those for the system and major subsystems. 4.1.3.C3: There should be a disciplined process to ensure that the technical system descriptions are integrated such that changes to any one that affects others is identified and tracked to conclus
96			3.3.6	Has a Work Breakdown Structure (WBS) been developed with the active participation of all relevant stakeholders, which accurately reflects both the hardware and the software product structure?	WBS	3.3.2	Work Breakdown Structure		3.3.2.Q2: For a joint and/or System of Systems (SoS) program, does the WBS identify and describe the "parent-child" type relationship? Note: Understanding the parent-child type relationship of various related programs and contracts and their impact on the WBS is important in the ever-increasing integrated and joint program environment. Often, individually base-lined programs and their various prime or GFE elements are actually part of a SoS approach. The overall parent program - the SoS or joint program, needs to be identified with the various child programs. Each child program would develop a stand-alone WBS structure [3.3.2.C1] 3.3.2.C9: The Contract WBS (CWBS) is the complete WBS as included in the DoD-approved PWBS extended to the agreed-to contract reporting level and any discretionary extensions to lower levels for reporting or other purposes. It adequately defines the lower level components of what is to be procured and includes all the product elements (hardware, software, data, or services), which are defined by the contractor.
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98		**3.3**		**Use of prototypes, exercises, models, and simulations to determine technological solution maturity**		3.1.1 3.2 4.2.3	Acquisition Strategy/Credibility Knowledge-Based Decisions and Milestones Technology Maturity and Integration		3.1.1.C3: The Acquisition Strategy documents the ground rules and assumptions under which the program was started and upon which future decisions will be gauged. It becomes more definitive over the execution of the program in describing the relationships of the following essential elements: -Simulation-Based Acquisition (SBA) – Acquisition strategy should address SBA, the robust and interactive use of modeling and simulation (M&S) throughout the product life cycle. 3.1.1.Q33: How does the Acquisition Strategy describe the PM's use of Simulation-Based Acquisition (SBA) throughout the product life cycle? Note: The PM should use SBA and M&S during system design, system T&E, and system modification and upgrade. In collaboration with industry and operational users, PMs should integrate SBA/M&S into program planning activities; should plan for life cycle application, support, documentation, and reuse of models and simulations; and should integrate SBA/M&S across the functional disciplines [3.1.1.C3] •Design Readiness Review. Knowledge should indicate that the product can be built consistent with cost, schedule, and performance parameters. This means design stability and the expectation of developing one or more workable prototypes or engineering development models.

				SE EM Framework Area	Interpretation	DAPS Section	DAPS Topic Covered	Comments/ Observations	References* *Not every reference is recorded here.
100			3.3.1	Will risky new technology mature before Milestone B? Is there a risk mitigation plan?		4.2.3	Technology Maturity and Integration		4.2.3.C4: The results of a demonstration/validation of new or advanced technologies quantify risk elements, and support the design strategy. A risk mitigation plan is initially developed to address the attendant risks, including adequate resources and schedule to accomplish planned mitigation activities. 4.2.3.Q7: What is the plan for the demonstration and validation of the proposed technologies and the quantifiable risks that remain to mature the technologies for system development and integration? •What are the risk mitigation plan and the resources required to validate (i.e., verification testing, modeling and simulation, etc)? [4.2.3.C4] Pre milestone B-- 4.2.3.C7: The SE process manages technology maturation within the context of the documented Technology Development Strategy (TDS), and manages the associated risk. 4.2.3.C8: Fiscal Year 2006, Public Law 109-163, Section 801 requires that the Under Secretary of Defense for Acquisition, Technology and Logistics (USD(AT&L)) certify, before Milestone B, that "the technology in the program has been demonstrated in a relevant environment." This wording immature critical technology, a more mature alternative technology has been identified in order to reduce the program risk if the immature technology does not mature as planned. This is described in the Critical Technology Element (CTE) maturation plan, which explains in detail how the required TRL will be reached prior to the next milestone decision date or relevant decision point. This plan includes the identification of adequate resources and schedule to accomplish planned mitigation activities.
101			3.3.2	Have the key non-technical risk drivers been identified and covered by risk mitigation plans?		3.2	Knowledge-Based Decisions and Milestones		The following knowledge points coincide with decisions along the acquisition framework: •Program Initiation. Knowledge should indicate a match between the needed capability and available resources before a program starts. In this sense, resources is defined broadly, to include technology, time, and funding. •Design Readiness Review. Knowledge should indicate that the product can be built consistent with cost, schedule, and performance parameters. The SRR is intended to confirm that the user's requirements have been translated into system-specific technological requirements, that critical technologies are identified, required technology demonstrations are planned, risks are well understood, and mitigation plans are in place [3.2.2.C7]

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103			3.3.3	Is there a sufficient collection of models, and appropriate simulation and exercise environments, to validate the selected concept and the CONOPS against the KPPs?		1.1.1 1.3	Mission Description Capabilities		1.1.1.Q17: Is there traceability among the CONOPS, the capabilities/requirements generation process, and system performance parameters to validate the end product through test and evaluation (T&E)? [1.1.1.C7] Capabilities Development Document (CDD). The CDD replaced the Operational Requirements Document. The CDD will be validated and approved before Milestone B. The CDD will be validated and approved prior to program initiation for shipbuilding programs. The CDD provides the operational performance attributes necessary for the acquisition community to design a proposed system(s) and establish a program baseline. It identifies the performance attributes, including Key Performance Parameters (KPPs), that guide the development and demonstration of the proposed system. Capability Production Document (CPD). The CPD is the sponsor's primary means of providing authoritative, testable capabilities for the Production and Deployment phase. A CPD is finalized after the design readiness review and must be validated and approved before the Milestone C acquisition decision.The CPD refines the threshold and objective values for the performance attributes and KPPs that are validated in the CDD for the production phase. The refinement of performance attributes and KPPs is the most significant difference between the CDD and CPD.
104			3.3.4	Has the claimed degree of reuse been validated?		3.3.4 4.5.1	Management Methods, Metrics, and Techniques Software Development Plan		3.3.4.3.C8: The Government Program Office should initially approve the program metrics and then periodically, e.g., monthly, the metrics should be reported and reviewed. These metrics should include many, if not all of the following: Development status S curves; Processor throughput utilization; Processor memory utilization; Input/output utilization; Software Engineering Staffing; Software Work Packages Summary; Schedule Performance Index; Cost performance Index; Problem/Deficiencies /Discrepancies Status; Requirements Stability; Software Size; **Software Reuse Status (planned versus 'actuals')**; Reliability Growth Curve; Logistics Footprint Reduction; Planned Operational Effectiveness; Product Availability Predictions; O&S Cost Projections; Development Test entrance criteria and status; DAES Reporting (For MDAPS); Milestone B and C entrance criteria. 4.5.1.C17: Reuse of software, from existing systems or prior development efforts, has been analyzed for complexity and suitability to meet required functionality, in accordance with accepted software engineering standards. Pre-Milestone C, this analysis has resulted in documented re-use in line with plans.
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106		**3.4**		**Validated system engineering, development, manufacturing, operations & maintenance budgets and schedules**		3.3.1	Program Plan/Schedule		• Integrated Baseline Review (IBR) – The IMS facilitates the conduct of a successful IBR, in which it is verified there is sound basis for cost and schedule execution of program objectives, program risks are addressed and the contractor has performance plans and underlying management control systems to assess the realism of the performance measurement baseline providing the required baselines.

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108			3.4.1	Are the major known cost and schedule drivers and risks explicitly identified, and is there a plan to track and reduce uncertainty?		2.1 2.2.1 3.1.2 3.2.2	Resources/Program Schedule Overview (TIER 1) Program Funding and Allocation Acquisition Strategy Entrance and Exit Criteria		Perspective: Experienced program personnel provide data regarding critical and high-risk efforts and identify as realistically as possible the expected schedule, which the program management office then compares with the top-level defense program schedule template to determine the actual schedule risk and to identify all schedule drivers. With this approach, the probability of overrunning a program schedule can be estimated by determining how much risk exists and where it is greatest. This approach enables program managers (PMs) to estimate early and continuously in the program the possibility of a significant likelihood of overrunning the program schedule by determining how much and where the risk to successful schedule completion is greatest. 2.2.1.Q13: Is the program, as captured in the CARD-like document, executable? • Does the CARD-like document capture the key program cost drivers, development costs (all aspects of hardware, human integration, and software), production costs, and operation and support costs? 3.1.2.C5: The Acquisition Strategy and specific acquisition approaches are consistent with operational capabilities/requirements and available resources, and appropriate to fully develop a system that meets the program objectives. • Program risks are identified and documented, and progress is tracked via established metrics that should be invariant with time. The end result is the overall risk of implementing the Acquisition Strategy is considered to be manageable within available time and resources. 3.2.2.Q48: Did the following result from the SRR? ... • A comprehensive risk assessment for the SDD phase • An approved SDD SEP that addresses cost and critical path drivers
109			3.4.2	Have the cost confidence levels been developed and accepted by the key system stakeholders?		2.2.2	Continuity and Stability	Assuming acceptance is implied because it was created with the contractors/stakeholders involved	pre all milestones: 2.2.2.C1: Flow of funding is stable and steady throughout the phases of the system's acquisition life cycle. The program manager (PM) and contractor plan for perturbations in the budget, both from within and outside their spectrum of control. Accordingly, the PM has taken the following minimal steps to achieve greater control over maintaining a stable budget: obtaining a high-confidence cost estimate that is well documented to firmly support budget requests; ensuring user advocacy for the program; ensuring that funding for the execution year(s) is consistent with the contractor's ability to expend the funding according to the current program schedule; and developing a range of independent estimates at completion from earned value data and analysis of the integrated master schedule. Compare the results with the contractor's projected final costs to assess realism and to form the basis for adjusting the program budget.

	SE EM Framework Area				Interpretation	DAPS Section	DAPS Topic Covered	Comments/ Observations	References* *Not every reference is recorded here.
111			3. 4. 3	Is there a top-to-bottom plan for how the total system will be integrated and tested? Does it adequately consider integration facilities development and earlier integration testing?		1.3.1 4.6.1	Reasonableness, Stability, and Testability Test and Evaluation Plan		The CPD captures the information necessary to support production, testing, and deployment of an affordable and supportable system within an Acquisition Strategy. The CPD refines the threshold and objective values for the performance attributes and KPPs that are validated in the CDD for the production phase. 4.6.1.C1: The program manager (PM) shall develop a robust integrated Test and Evaluation Strategy (TES) for all phases of the program, describing developmental test and evaluation (DT&E), operational test and evaluation (OT&E), and live-fire test and evaluation (LFT&E). Without compromising rigor, the program is required to integrate modeling and simulation (M&S) activities into the strategy. The TES should be consistent with and complementary to the Systems Engineering Plan (SEP). 4.6.1.C3: The system integration, test and evaluation process is defined in the Technology Development Strategy (TDS) and includes analysis, reviews, inspections, demonstrations, testing, and M&S to evaluate the requirements baseline and the system's progress during development to meet the critical technical parameters (CTPs). The TES describes an iterative process by which allocated specifications and CTPs are met by lower-level components, assemblies, subsystems and then at the system level. Requirements are traceable to specific test and evaluation events. 4.6.1.C7: Integration test facilities that allow demonstration of hardware and software operation at progressively higher levels of integration are used/planned during TD.
112			3. 4. 4	If time-boxing or time-determined development is used to stabilize schedules, have features been prioritized and the system architected for ease of adding or dropping borderline features?		4.2.2 1.3 2.2	Management of Requirements Capabilities Constraints and Dependencies	DAPS does not address "prioritized" requirements but requires a fexible process that supports change when needed. It also recommends a modular and open architecture to facilitate change. Time-boxing or time-determined development is not mentioned, but it mentions accomodating constraints of time. It also recommends a time reserve.	4.2.2.C10: The evolutionary Acquisition Strategy (AS) utilizes a management system that continually defines the requirements and development activities to support the evolving needs; adequately addresses the various concerns of users, developers, and managers; and mitigates the risks associated with these issues. The basic system architecture is designed to accommodate change. Techniques such as open systems design, functional partitioning and modular design have been addressed by the PM to achieve a flexible system that can be easily and affordably modified. 1.3: New capabilities are defined within the "art of the possible" and grounded within real-world constraints of time, technology, and affordability. 1.3.1.C1: Milestone A review . . . The ICD clearly states required capabilities in broad and time-phased operational goals. 2.1.2.C1. . .The end result is a program schedule that has inherent flexibility to accommodate the competing demands of time and resources while ensuring the best capability to the warfighter. Note: Constraints are effectively global requirements, such as limited development resources or a way a system is developed. Constraints can be economic, political, technical, or environmental and pertain to program resources, schedule, environment, or to the system itself.

	SE EM Framework Area				Interpretation	DAPS Section	DAPS Topic Covered	Comments/ Observations	References* *Not every reference is recorded here.*
114			3.4.5	Are there strategies and plans for evolving the architecture while stabilizing development and providing continuity of services?		4.1.2 4.2.2	Modular Open Systems Approach Management of Requirements		4.1.2.C1: Certain capabilities, requirements, and program strategies/objectives necessitate implementing open systems and developing open architectures. DoDD 5000.1 requires that a modular open systems approach (MOSA) be employed where feasible. The program should identify open architecture enabled capabilities/objectives that reflect the following MOSA objectives (see the MOSA PM Guide at (http://www.acq.osd.mil/osjtf/pmguide.html): 1. Facilitate a modular architecture to allow for affordable interoperability 2. Ensure a flexible and robust system design to accommodate changing technology and requirements 3. Facilitate integration with other systems and use of commercial products from multiple sources both in the initial design and in future enhancements 4. Enable technology insertion as currently available commercial products mature and new commercial products become available in the future 4.2.2.C10: The evolutionary Acquisition Strategy (AS) utilizes a management system that continually defines the requirements and development activities to support the evolving needs; adequately addresses the various concerns of users, developers, and managers; and mitigates the risks associated with these issues. The basic system architecture is designed to accommodate change. Techniques such as open systems design, functional partitioning and modular design have been addressed by the PM to achieve a flexible system that can be easily and affordably modified.
115									
116	**4 Evidence-based progress monitoring and commitment reviews**					3.3.4 4.3.1	Management, Methods, Metrics, and Techniques Technical Review Planning		Sub-Factor 3.3.4.3 – Technical Performance Measures Pre-Milestone B & C Criteria 3.3.4.3.C1: Systems engineering uses technical performance measurements to balance cost, schedule, and performance throughout the life cycle. Technical performance measurements compare actual versus planned technical development and design. They also report the degree to which system requirements are met in terms of performance, cost, schedule, and progress in implementing risk handling. Performance metrics are traceable to user-defined capabilities. Factor 4.3.1 – Technical Review Planning All Acquisition Category (ACAT) programs should include the essential technical reviews shown on the timeline, as applicable. Technical reviews provide a systematic process for continuously assessing the technical baseline, design maturity, technical risk, and programmatic risk of acquisition programs. Technical reviews are consistent with existing and emerging commercial and industrial standards and form the backbone of an effective Systems Engineering Plan (SEP).
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118		**4.1**		**Monitoring of system definition & development progress vs. plans**		2.1	Program Schedule Overview		"As the program progresses, the PM monitors the effectiveness of handling activities included in the integrated planning events and schedule by comparing observed activity results with their criteria and determining any deviations from the planned schedule."

	SE EM Framework Area				*Interpretation*	*DAPS Section*	*DAPS Topic Covered*	*Comments/ Observations*	*References** **Not every reference is recorded here.*
120			4.1.1	Are the levels and formality of plans, metrics, evaluation criteria, and associated mechanisms (IMP, IMS, WBS, EVMS) commensurate with the level of project requirements emergence and stability? (Too little is risky for pre specifiable and stable requirements; too much is risky for emergent and unstable requirements.)		3.3.4	Management Methods, metrics, and Techniques	Not clear what "level of project requirements emergence" means. Needs clarification. In DAPS, levels of formality specified by size of project, not necessarily stability of requirements.	3.3.4.2.C1: EVM is required on all cost or incentive type acquisition contracts, subcontracts, intra-government work agreements, and other agreements according to dollar thresholds prescribed in USD(AT&L) Policy Memorandum dated March 7, 2005. The thresholds are as follows: •$20 million or greater – EVM implementation compliant with ANSI/EIA – 748 - A is required. No formal EVM System (EVMS) validation is required •$50 million or greater – EVM implementation compliant with ANSI/EIA – 748 - A is required. An EVM System must be formally validated and accepted by the cognizant contracting officer • A Contract Performance Report (CPR) and Integrated Master Schedule (IMS) are required deliverables for all contracts that are $20 million or greater that require EVM • Less than $20 million – EVM is not required, except at the discretion of the PM
121			4.1.2	Are the project's staffing plans and buildup for progress monitoring adequate with respect to required levels of expertise?		2.1.1 2.3.1	Program Schedule/Viability Sufficiency of Numbers and Qualifications	Not sure what "buildup for progress monitoring" means.	2.1.1.C1: . . .The program manager (PM) has utilized subject matter expertise of the stakeholders and the following processes to develop the program schedule: 2.1.1.Q26: What are the changes in the personal experience and subject matter expertise of the IPT members involved in the development of the program schedule? 2.3.1.Q1: Is there a staffing plan established? • What is the process to determine personnel resources and phasing required for the development of the staff, including skills, experience, and education level? • What are the metrics and standards used to measure the quality of the workforce? [2.3.1.C1] 2.3.1.Q18: What is the experience level of each of the existing or planned key technical personnel? • What engineering expertise is required for the program? • How is the experience of technical personnel relevant to the current activity? [2.3.1.C3]
122			4.1.3	Have most of the planned project personnel billets been filled with staff possessing at least the required qualification level?		2.3.1	Sufficiency of Numbers and Qualifications		2.3.1.Q3: How does the PMO describe the personnel issues affecting the program's ability to successfully execute the program? • What key specialties are missing? • What key billets are unfilled/about to be vacated? [2.3.1.C1] 2.3.1.Q4: What is the experience level of each of the existing or planned key technical personnel? How is the experience of technical personnel relevant to the current activity? [2.3.1.C1]
123			4.1.4	Is the project adequately identifying and managing its risks?		3.3.4	Management Methods, metrics, and Techniques		Sub-Factor 3.3.4.1 - Risk Management 3.3.4.1.C1: The Department of Defense (DoD) recognizes that risk management is critical to acquisition program success (see the Defense Acquisition Guidebook (DAG). 3.3.4.1.C2: There are several notable changes of emphasis in the above guide from previous RM versions. These changes reflect lessons learned from application of risk management in DoD programs. Emphasis has been placed on: • The role and management of future root causes, • Distinguishing between risk management and issue management, •Tying risk likelihood to the root cause rather than the consequence, •Tracking the status of risk mitigation implementation versus risk tracking, and •Focusing on event-driven technical reviews to help identify risk areas and the effectiveness of ongoing risk mitigation efforts.

				SE EM Framework Area	*Interpretation*	*DAPS Section*	*DAPS Topic Covered*	*Comments/ Observations*	*References** **Not every reference is recorded here.*
125			4.1.5	Have the processes for conducting reviews been evaluated for feasibility, reasonableness, completeness, and assurance of independence?		4.3.1 1.3.1 4.1.1	Technical Review Planning Reasonableness, Stability, and Testability System Assurance	States that the reviews are held, "as applicable" Independent assessments are performed throughout, but the contractor's processes for conducting reviews is not really addressed except by the SEP.	Factor 4.3.1 – Technical Review Planning All Acquisition Category (ACAT) programs should include the essential technical reviews shown on the timeline, as applicable. Technical reviews provide a systematic process for continuously assessing the technical baseline, design maturity, technical risk, and programmatic risk of acquisition programs. 1.3.1.C14: Computer/software configuration items have completed test verification, and the system software capability is determined to be mature. All known deficiencies have been documented and evaluated, and fixes have been identified and rescheduled for verification. An Independent Verification and Validation (IV&V) assessment of the contractor/materiel developer has been performed. 4.3.1.C3: The ITR ensures that a program's technical baseline is sufficiently rigorous to support a valid cost estimate (with acceptable cost risk), and enable an independent assessment of that estimate by cost, technical, and program management subject matter experts. 4.3.1.C15: The SRR is typically conducted by a technical review board consisting of a government chairperson selected outside (independent of) the government program office. 4.3.1.Q32: For ACAT ID or IAM programs, the service acquisition official provides a recommendation to the Director, Defense Research and Engineering (DDR&E) of the Office of the Secretary of Defense for Deputy Under Secretary of Defense for Science and Technology (DUSD(S&T)) final approval. If deemed necessary, the DDR&E can conduct an Independent Technical Assessment (ITA) in addition to, and totally separate from, the TRA: 4.3.1.C56: Prior to the OTRR the OUSD(AT&L) Systems and Software Engineering/ Assessments and Support (SSE/AS) staff will conduct an assessment of operational test readiness (AOTR) to independently assess the successful completion of developmental test and evaluation (DT&E) and report the AOTR findings to the PM and Deputy, OUSD(A&T). 4.4.2.C7: Government and contractor use common M&S tools to support both development and test and evaluation. Simulations used to evaluate program performance as part of the test and evaluation process are verified independently from contractor simulations and undergo the same level of verification, validation, and accreditation (VV&A). 4.5.2.Q3: How will the various program estimates be vetted? How similar/different are the program's cost and schedule estimates and associated assumptions to other estimates (e.g. the Cost Analysis and Information Group's (CAIG) independent cost estimate (ICE))?
126			4.1.6	Has compliance with legal, policy, regulatory, standards, and security requirements been clearly demonstrated?		3.2.1 3.2.3 3.4	Statutory and Regulatory Compliance and Guidance Certifications Contract Management	This question seems too vague. It assumes a lot of knowledge and can pertain to reporting mechanisms, processes, government and contract conduct,	3.2.1.Q10: Does the PMO have a clear and concise understanding of all DoD and Service-level policies and statutes that the program must comply with? [3.2.1.C4] 3.2.1.Q11: Have the following statutory information requirements been met? Who is the approval authority and what is the approval date? Note: See DAG for applicable statutes for each information requirement. •Consideration of technology issues
127									
128		**4.2**		**Monitoring of feasibility evidence development progress vs. plans**		2.1.1 3.2.1	Viability Statutory and Regulatory Compliance and Guidance		2.1.1.Q9: What is the process established to monitor program performance through the schedule? •Are the following identified? -Key events - Milestones -Reviews -All integrated technical tasks -Accomplishment criteria and schedule metrics [2.1.1.C2]

	SE EM Framework Area				Interpretation	DAPS Section	DAPS Topic Covered	Comments/ Observations	References* *Not every reference is recorded here.
130			4. 2. 1	Has the project identified the highest risk areas on which to focus feasibility analysis?		2.1.1 3.2.2 3.3.6 3.3.4.1	Viability entrance and Exit/Success Criteria Management of Dependencies and External Interfaces Risk Management		2.1.1.Q17: What is the highest risk path, both for the overall program schedule and for the SDD schedule? •How has the PM applied resources against the activities on this risk path? [2.1.1.C3 and 2.1.1.C4] 3.2.2.Q32: In preparation for the SRR, were the following actions completed? • Successful completion of all post-award activities • Published agenda (several weeks prior to the conference – to permit sufficient time for government preparation • Draft system specification and any initial draft performance item specifications • Functional analysis (top level block diagrams) • Feasibility analysis (results of technology assessments and trade studies to justify system design approach) 3.3.4.1.C1: The Department of Defense (DoD) recognizes that risk management is critical to acquisition program success (see the Defense Acquisition Guidebook (DAG). The purpose of addressing risk on programs is to help ensure program cost, schedule, and performance objectives are achieved at every stage in the life cycle and to communicate to all stakeholders the process for uncovering, determining the scope of, and managing program uncertainties. Since risk can be associated with all aspects of a program, it is important to recognize that risk identification is part of the job of everyone and not just the program manager or systems engineer. That includes the test manager, financial manager, contracting officer, logistician, and every other team member.

	SE EM Framework Area				Interpretation	DAPS Section	DAPS Topic Covered	Comments/ Observations	References* *Not every reference is recorded here.
132			4. 2. 2	Has the project analyzed alternative methods of evaluating feasibility (models, simulations, benchmarks, prototypes, reference checking, past performance, etc.) and prepared the infrastructure for using the most cost-effective choices?		1.2.1 1.2.2 1.3 2.1.1 3.4.3 4.2.4	Validity and Currency Linkage and Traceability Capabilities Program Schedule/Viability Value Engineering Trade Studies and Approches		1.2.1.Q1: How were mission tasks (MTs), measures of effectiveness (MOEs), and measures of performance (MOPs) derived from relevant guidance on requirements or capabilities (e.g., Mission Needs Statement (MNS), Operational Requirements Document (ORD) (if pertinent), or the problem statement found in the ICD? [1.2.1.C1] •Are they quantifiable? [1.2.1.C1] 1.2.1.Q7: What are the models and simulations used in the study? •Are they acceptable and accredited? [1.2.1.C1] 1.2.2.C1: The Analysis of Alternatives (AoA) study plan describes a clear link between the AoA, capability needs, system requirements, and the measures of effectiveness (MOEs) used to evaluate the system(s). 1.2.2.Q13: How does the program use realistic and current architectures and the CONOPS to derive alternative solutions and to ensure a clear understanding of potential C4I interfaces and interoperability needed during military operations? •Initial Capabilities Document (ICD) . . . supports the Analysis of Alternatives (AoA), Technology Development Strategy (TDS), Milestone A decisions, and subsequent Technical Development (TD) phase activities. 2.2.1.Q14: What were the results of the Alternative System Review (ASR)? • Did the IPT determine that the operational capabilities, preferred solution(s), available technologies, and program resources (funding, schedule, staffing, and processes) form a satisfactory basis for proceeding into the TD phase? •Is the program schedule executable (technical and/or cost risks)? [2.2.1.C2] 3.1.1.Q23: How did the Acquisition Strategy address risk management? ... •What statistical or other qualitative procedures were followed to “measure” program risk? •What is the risk management structure for selecting acquisition alternatives? [3.1.1.C3] 3.4.3.Q23: How did the government and contractor, through the VE process, analyze the essential requirements, military and technical characteristics, and the design tasks to develop possible alternatives offering improved value? 4.2.4.Q8: What is the planned role of modeling and simulation (M&S) to support trade studies?

	SE EM Framework Area				Interpretation	DAPS Section	DAPS Topic Covered	Comments/ Observations	References* *Not every reference is recorded here.
134			4.2.3	Has the project identified a full set of representative operational scenarios across which to evaluate feasibility?		1.2.1 4.1.8 4.4.2	Validity and Currency Human Systems Integration Modeling and Simulatioin Tools		1.2.1.Q1: How were mission tasks (MTs), measures of effectiveness (MOEs), and measures of performance (MOPs) derived from relevant guidance on requirements or capabilities (e.g., Mission Needs Statement (MNS), Operational Requirements Document (ORD) (if pertinent), or the problem statement found in the ICD? [1.2.1.C1] •Are they quantifiable? [1.2.1.C1] 1.2.1.Q2: Are the MOEs stated in terms of military utility and based on value provided to the warfighter? •Are these MOEs used to identify models, simulations, and other analysis tools required to execute the study? [1.2.1.C1] 1.2.1.Q3: What are the relevant issues and constraints as addressed in the study plan? [1.2.1.C1] 1.2.1.Q4: Is the range of alternatives comprehensive? [1.2.1.C1] 1.2.1.Q5: Are the threats and scenarios realistic and current? [1.2.1.C1] 1.2.1.Q15: Were the threats and scenarios used in the study appropriate and approved by Defense Intelligence Agency (DIA)? 4.1.8: • Are scenario-based factors such as environmental conditions, conflict durations, etc. included? [4.1.8.C1, C2] 4.4.2.C5: The program has a plan to acquire domain knowledge for each M&S objective-scenario set. This domain knowledge includes the entities, attributes and interactions that have significant bearing on the objective at the level of resolution and fidelity required for the effort.
135			4.2.4	Has the project prepared milestone plans and earned value targets for measuring progress in developing feasibility evidence?		3.3.1	Program Plan/Schedule	Unclear if this means establishing thresholds for the schedule and cost metrics. Target values are not discussed in DAPS	3.3.1.C7: The program has appropriate development activities planned and scheduled, e.g. Integrated Master Plan/Integrated Master Schedule (IMP/IMS), and implements these activities to execute the program. These planned and scheduled activities include completion criteria. Program funding and schedules are sufficient to accommodate technical complexity and identified program risks. Sufficient resources are allocated and available to the program to successfully develop the system within the program baseline. 3.3.1.C8: The program is following the program management plans in executing the program. The program has accomplished/is accomplishing the planned activities with minimal schedule impact and is proceeding to execute within the program baselines. Schedule performance is reported through an Earned Value Management System (EVMS).

	SE EM Framework Area				*Interpretation*	*DAPS Section*	*DAPS Topic Covered*	*Comments/ Observations*	*References** ***Not every reference is recorded here.***
137			4.2.5	Is the project successfully monitoring progress and applying corrective action where necessary?		3.4.1 4.6.1	Contracting/Prime Contractor Management Test and Evaluation Plan		3.4.1.C5b: Design and Production Assurance – monitor the performance of the contractor against contract requirements to enable timely corrective action. 3.4.1.Q74: In terms of Integrated Baseline Reviews (IBRs): • How did the contractor address the government's intent to conduct IBRs after contract award? • Who developed the guidelines, criteria, and processes for the IBR? • Who lead the technical assessments during IBRs? • Upon completion, how are the results of the IBR documented and provided to appropriate team members? • What action plan is prepared to correct any problem areas discovered during the review? •What is the process to track corrective actions and interfaces with the contractor during program reviews until the corrective actions are completed? [3.4.1.C5b] 4.6.1.C11: A Failure Reporting, Analysis and Corrective Action System (FRACAS) has been initiated. The systems engineering (SE) process provides tracking between test activities and technical requirements. • Discuss the planned FRACAS program. What is the planned time for root cause analysis and corrective action for major and minor hardware/software deficiencies? [4.6.1.C19, 4.6.1.C20, and 4.6.1.C22]
138									
139		**4.3**		**Monitoring, assessment, and replanning for changes in needs, opportunities, and resources**					

	SE EM Framework Area				Interpretation	DAPS Section	DAPS Topic Covered	Comments/ Observations	References* *Not every reference is recorded here.
141			4.3.1	Does the project have an effective strategy for performing triage (accept, defer, reject) on proposed changes, which does not destabilize ongoing development?		1.3.1 2.1.1 3.1.1 3.2.2 3.3.1 3.3.6 3.4.1	Reasonableness, Stability, and Testability Program Schedule/Viability Acquistion Strategy/Credibility Entrance and Exit/Success Criteria Program Plan/Schedule management of Dependencies and External Interfaces Prime contractor Management	DAPS discusses allowing for and managing change but does not present methods for doing so like triage.	1.3.1.Q8: Were any changes made to the ICD between JROC approval and the Milestone A decision review? •How were these changes vetted through the requirements generation and acquisition management processes? 1.3.1.Q17: What controls are in place to prevent “requirements creep” and to force new requirements to be defined through an engineering change proposal process? [1.3.1.C5] 2.1.1.C1: The program’s overall schedule is viable (i.e., workable and has real meaning and pertinence).. . . • Implementation of procedure(s) to control changes to the program schedule.. . . •Revision of the procedure(s) to control changes to the program schedule, if required. 2.2.1.Q4: What is the PM’s process to prevent unexpected or unplanned cost growth by adequately identifying and managing risks in the program? • What is the process to allocate funding (level and timeliness) to cover: - Systems Engineering (SE) technical reviews - Risk mitigation - Engineering changes 3.1.1.Q4: Are any of the potential causes of instability to the Acquisition Strategy present? If so, how is the PM working to mitigate the impact to the program’s Acquisition Strategy? 3.1.1.Q5: How is the PM emphasizing the following “aids” to a stable Acquisition Strategy? • Direction. • Advocacy. • Commitment. •Use of Integrated Product Teams. 3.3.1.Q9 What are the in place processes to manage the Technology Development (TD) phase effort and cont 3.3.6.Q15: How are changes in SoS constituent systems negotiated with their PMs? [3.3.6.C14] 3.4.1.C5: The program’s third phase – execution and sustainment - is being successfully completed through in 3.4.1.Q71: How are Engineering Change Proposals (ECPs) and alterations affecting cost and schedule addresse • Are the changes within the scope of the contract? •Was pricing information to support the ECP requested from the contractor? •After Change Control Board approval, were the following issued? -The change request for implementing the change -Contract deliverable data requirements -Sole source authorization if required -Funding documents to be used [3.4.1.C5b]

	SE EM Framework Area				*Interpretation*	*DAPS Section*	*DAPS Topic Covered*	*Comments/ Observations*	*References** **Not every reference is recorded here.*
143			4.3.2	Does the project have an adequate capability for performing change impact analysis and involving appropriate stakeholders in addressing and prioritizing changes?		1.3.1 2.1.1 3.1.1 3.2.2 3.3.1 3.3.6 3.4.1	Reasonableness, Stability, and Testability Program Schedule/Viability Acquistion Strategy/Credibility Entrance and Exit/Success Criteria Program Plan/Schedule management of Dependencies and External Interfaces Prime contractor Management		3.2.2.Q61: In preparation for the PRR, were the following activities/actions completed or documents/information available? •Provisions have been made for determining producibility and cost impacts of engineering changes introduced during production 3.4.1.C5: The program's third phase – execution and sustainment - is being successfully completed through insight into program progress, and the effective management of the impact of changes, whether these changes are due to contract execution or to external influences. As the program progresses, the PM makes viable and timely decisions and provides direction to accommodate changing circumstances. Focus is maintained on the risk areas most likely to impact the program. The PM uses those indicators developed in the previous stages, i.e., EVMS, IMS and appropriate metrics, for primary program insight. 4.2.2.Q6: How is the requirements management process during TD supported by the resource management tools? •When changes are made, how are the impacted requirements identified and accounted for in the updated system? [4.2.2.C8] 4.2.3.Q3: For a system of systems (SoS) and family of systems (FoS), what is the process used to assess the impact of incorporating a new capability within the hierarchy of systems? [4.2.3.C1]
144			4.3.3	Is the project adequately verifying and validating proposed changes for feasibility and cost-effectiveness?		1.3.1 2.1.1 3.1.1 3.2.2 3.3.1 3.3.6 3.4.1	Reasonableness, Stability, and Testability Program Schedule/Viability Acquistion Strategy/Credibility Entrance and Exit/Success Criteria Program Plan/Schedule management of Dependencies and External Interfaces Prime contractor Management		See above.
145									
146		**4.5**		**Use of milestone reviews to ensure stakeholder commitment to proceed**					

	SE EM Framework Area				Interpretation	DAPS Section	DAPS Topic Covered	Comments/ Observations	References* *Not every reference is recorded here.*
148			4.5.1	Are milestone review dates based on the availability of feasibility evidence, instead of the availability of artifacts or the occurrence of planned review dates?		3.2 3.2.2 3.3.1	Knowledge-based Decisions and Milestones Entrance and Exit/Success Criteria Program Plan/Schedule	The DAPS specifies reviews based on entrance and exit criteria. These entrance and exit criteria are activities that need to be accomplished (e.g., requirements are traceable…) not schedule or artifacts. Same with the master plan and schedule.	Knowledge-based acquisition is a management approach that requires adequate knowledge at critical junctures (i.e., knowledge points) throughout the acquisition process to make informed decisions. The following knowledge points coincide with decisions along the acquisition framework: . . . • Entrance Criteria: Each phase has defined entrance criteria that are based on the definition and validation of needed capabilities, technology maturity, system design maturation, and funding. Major decision points (e.g. MS B, C) mark the entrance into succeeding phases, with specific decision points tailored on a program-by-program basis and supported by technical and programmatic reviews. 3.2.2.C7: Entrance Criteria into technical and programmatic reviews (e.g., IBR, SRR, System Functional Review (SFR), Software Specification Review (SSR), Preliminary Design Review (PDR), Design Readiness Review (DRR), Critical Design Review (CDR), Test Readiness Review (TRR), System Verification Review (SVR), Production Readiness Review (PRR), and TRA), in support of specific decision points conducted during the SDD phase, have been successfully met. 3.2.2.C8: Exit/Success Criteria from TD phase: Successful development, maturation, and evaluation of the technologies needed for the capability under consideration. The maturation of the required technologies is consistent with the prescribed Technology Readiness Levels (TRLs). 3.2.2.C9: Exit/Success Criteria for technical and programmatic reviews conducted during TD phase (i.e., SRR, IBR and TRA), in support of decision points were successfully conducted with valid documentation, data, and analyses. 3.3.1.C1: The Integrated Master Plan (IMP) is an event-driven plan that documents the significant accomplishments necessary to complete the work and ties each accomplishment to a key program event that forms the foundation of the Integrated Master schedule (IMS). Note: The IMP Events are not tied to calendar dates; each event is completed when its supporting Accomplishments are completed and as evidenced by the Criteria completion supporting each of those Accomplishments.

	SE EM Framework Area				*Interpretation*	*DAPS Section*	*DAPS Topic Covered*	*Comments/ Observations*	*References* *Not every reference is recorded here.*
150			4.5.2	Are artifacts and evidence of feasibility evaluated, and risky shortfalls identified, by key stakeholders and independent experts, prior to review events?		2.2.1 3.1.1 4.5.1	Program Funding and Allocation Acquisition Strategy/Credibility Software Development Plan	The DAPS discusses this in detail for every review. However, it does require that artifacts be submitted to the government in preparation for the review. Entrance and Exit Criteria for reviews are not discussed in detail	•Initial Capabilities Document (ICD). The ICD replaced the Mission Needs Statement. The ICD documents the need for a materiel approach to a specific capability gap derived from an initial analysis of materiel approaches executed by the operational user and, as required, an independent analysis of materiel alternatives. 2.2.1.Q11: What were the results of the Initial Technical Review (ITR)? •Is the program's technical baseline sufficiently rigorous to support a valid cost estimate (with acceptable cost risk)? •How does it enable an independent assessment of the estimate by cost, technical, and program management subject matter experts? 3.1.1.Q34: How does the Acquisition Strategy address key aspects, including risks, of the proposed software development approach? •Does it state how the chosen software development approach supports the system-level Acquisition Strategy? •What is the plan for using independent expert reviews for a software-intensive program? [3.1.1.C3] Design Considerations 4.5.1.C18: The software development has followed a disciplined process documented in the program SDP and related plans. This process includes reviews, design, implementation and integration and test. Reviews have proceeded based on documented entrance and exit criteria and results are captured in minutes and updates to plans, artifacts, design, and code. Tools and facilities exist and are used to execute the software development and verification (testing). The current status of software completion verification testing is consistent with the verification test schedule. 3.2.2.Q30: In preparation for the IBR, were the following documents provided by the contractor to the government for review? (SOW, WBS, CWBS, CAPs . . .)
151			4.5.3	Are developer responses to identified risks prepared prior to review events?		3.2.2	Entrance and Exit/Success Criteria	Identifying risks is mentioned as entrance criteria, but it does not specify that developer responses must be prepared prior to review events	
152			4.5.4	Do reviews achieve risk-based concurrence of key stakeholders on whether to proceed into the next phase? (Proceed; skip a phase; revisit the current phase; terminate or rescope the project.)		3.2.2 4.3	Entrance and Exit/Success Criteria Technical Baselines	DAPS process ensures stakeholder review/concurrence at all major milestones	Figure 4.3 Systems Engineering Technical Review Timing

APPENDIX F: SERC SE EM: PROPOSED NEW FRAMEWORK

2/16/2009

At our January 29-30 Workshop, we encountered three candidate frameworks for organizing our systems engineering (SysE) effectiveness measures (EMs):

1. The 5x5 matrix based on the DoD SysE Plan Preparation Guide and included in our EM task proposal, for which we had prepared in instrument for evaluating the functional coverage of the 8 Candidate EM approaches we are in the process of evaluating.

2. Another 5x5 matrix developed by the US-UK-Australia Software-Intensive Systems Acquisition Improvement Group (SISAIG), to serve as a review framework for identifying early warning indicators for troubled projects. It was expanded by USC into a Macro Risk Tool for NASA projects, in which each of the 25 elements have a set of subsidiary questions about sources of project risk. The tool is tailorable to different projects by assigning different weights to the questions. It was proposed at the January Workshop as a tool framework for projects to use in applying the end-result EMs from the SERC task to DoD project reviews.

3. The 45-row Candidate EM Coverage Matrix providing an initial USC assessment of which individual EMs were covered by which Candidate EM approaches. It was found at the Workshop to be a good way to compare the candidate EM approaches, subject to having the EM approach originators update the USC assessments, and subject to finding a better organization for the 45 items.

After the Workshop, we performed crosswalks among the three frameworks, and synthesized the proposed new framework shown on the next page. It is a bit simpler than the 5x5s, having 4 major categories and 4-5 elements per category. It also identifies the counterpart EM items in the three frameworks above, showing both their overlaps and their candidate subsidiary questions to ask about sources of project risk. The category elements are not mutually exclusive (topics such as COTS and reuse arise in several contexts, for example), but they are reasonably orthogonal, and they are exhaustive in that they cover all of the EM items in the three frameworks above.

We propose to use the new framework as the organizing principle for a revised SysE EM Macro Risk Tool. However, we would propose to proceed to use the Coverage Matrix in doing each team member's assessments of the strength of each Candidate EM approach in addressing each Coverage Matrix element on a Green-Yellow-Orange-Red basis as was done in Joe Elm's and Paul Componation's self-assessments. Once we discuss and reconcile or note differences in evaluators' ratings, we can then populate the Coverage Matrix items into the new EM framework, and revise the Macro Risk Tool to serve as a review-oriented EM evaluation tool.

Systems Engineering Effectiveness Measurement Proposed New Framework	SEPP-Guide-Based Eval. Framework	SISAIG/ Macro Risk Framework	Coverage Matrix Items
1. Concurrent Definition of System Requirements & Solutions			
1.1 Understanding of stakeholder needs: Capabilities, Operational Concept, Key Performance Parameters, Enterprise fit (legacy)	1.1, 1.4, 3.1	1.1, 1.4	5, 7, 22, 36, 37
1.2 Concurrent exploration of solution opportunities; AoA's for cost-effectiveness & risk (Measures of Effectiveness)	4.1, 4.2	1.2	1, 14, 26, 27, 28
1.3 System scoping & requirements definition (External interfaces; Memoranda of Agreement)	1.2, 1.4	3.2	4, 6, 13, 50
1.4 Prioritization of requirements & allocation to increments	1.3	1.5	2, 11, 31

2. System Life Cycle Organization, Planning, Staffing			
2.1 Establishment of stakeholder Life Cycle Responsibility, Authority, and Accountabilities (RAAs) (for System Definition, System Development, System Operation)	2.1	2.1, 2.3, 2.5	2, 17, 20, 46
2.2 Establishment of Integrated Product Team (IPT) RAAs, Cross-IPT coordination needs	2.2	2.2, 2.4	32
2.3 Establishment of necessary resources for meeting objectives	3.5, 4.2, 4.6	2.4	9, 40
2.4 Establishment and usage support of appropriate source selection, contracting, & incentive structures	2.1	2.1, 2.5	21, 33, 42
2.5 Assurance of necessary personnel competencies	3.2, 3.3, 3.4	2.4, 2.6	16, 19, 20, 23

3. Technology Maturing, Architecting			
3.1 COTS/NDI/Services evaluation, selection, validation for capability, maturity & compatibility	4.5	3.5	28
3.2 Life Cycle architecture definition & validation	4.1, 4.2	1.2, 3.2, 3.4	1, 12, 13, 14, 30, 39, 44

3.3 Use of prototypes, exercises, models, and simulations to determine technology maturity, architecture feasibility	4.3, 4.5	3.3, 3.5	3, 10, 15, 26, 27, 28
3.4 Validated System Engineering, Development, Manufacturing, Operations & Maintenance budgets & schedules	4.4	3.3, 5.1	8, 9, 18

4. Evidence-Based Progress Monitoring & Commitment Reviews			
4.1 Monitoring of system definition & technical development progress vs. plans	5.1, 5.2	4.4, 4.5, 5.2, 5.5	23, 24, 25, 29, 38, 41, 43, 44, 45
4.2 Monitoring of feasibility evidence development progress vs. plans	5.3	3.3, 5.4	8, 26, 27, 29, 30, 49
4.3 Monitoring, assessment, and replanning for changes in needs, opportunities, and resources	2.2, 5.4, 5.6	1.5, 5.3	30, 34, 35, 40, 41
4.4 Identification and mitigation planning for feasibility evidence shortfalls and other risks	4.3, 5.2, 5.3	1.2, 5.4	8, 15, 47, 48
4.5 Use of milestone reviews to ensure stakeholder commitment to proceed	4.6	4.1, 4.2, 4.3, 4.4, 4.5	9, 51

APPENDIX G: EVOLUTION OF THE EM PROJECT PLANS AND SCHEDULES

1. Sponsor Guidance

The initial guidance provided in the Request for Proposal and contract Statement of Work was to develop SE EMs suitable for use by contractor management, DoD program managers, and DoD oversight officials in evaluating the effectiveness of a project's systems engineering activities across the range of weapons platforms, systems of systems, and net-centric services. The final guidance provided by the ultimate task sponsors can be summarized as to: Focus Initial Task Pilot Evaluations and Recommendations on Major Defense Acquisition Programs (MDAPs); Develop and Iterate a Coverage Matrix; Develop a Framework, Operational Concept, and Tools; and to relate these to the Defense Acquisition Program Support (DAPS) Methodology

Our Office of the Under Secretary of Defense (Acquisition, Technology, and Logistics) (OUSD(AT&L)) sponsors initially saw the greatest near-term need for EMs in the Weapons Platform domain. They asked us to structure the evaluations to enable them to be used in potential follow-on tasks for the System of Systems and Net-Centric Services domains, but to focus our pilot evaluations and recommendations on Weapons Platforms. This changed each team member's Statement of Work accordingly, and initially enabled us to develop more thorough results for the Weapons Platform domain.

In a subsequent telephone conference on January 9, our sponsors indicated that they would like to see more up-front work done on the survey and interviews, and on a coverage matrix indicating which EMs cover which individual candidate measures of effectiveness. They preferred to have us focus a planned January 29-30 workshop on a SERC-internal assessment of progress to date on these, to defer the SERC-external workshop involving potential EM users and pilot candidates until late March-early April (March 30-April 3 week proposed) and to do one round of pilot evaluations rather than two. The University of Southern California, USC, developed a framework and performed the coverage matrix subtask.

At the January 29-30 workshop, the coverage matrix was found to provide a good basis both for comparison of the candidate EMs and as an improved framework for EM evaluation, subject to having the EM originators iterate the USC assessments of their coverage, adding a strength-of-coverage rating level, and reorganizing the coverage list into an evaluation framework. USC therefore revised the framework and the evaluation instrument. Based on further initial sponsor guidance, our plans were revised to add a Personnel Competency EM, to reassign Massachusetts Institute of Technology (MIT)'s tasks, due to MIT's inability to participate in the SERC, and to show the new schedule of activities and results.

At the May 6 workshop and a follow-on May 7 meeting, the sponsors indicated that it would be valuable to relate the EM framework to the DAPS Methodology, and to perform the EM evaluation with respect to the DoD Systemic Analysis Database (SADB) by furnishing questions to the SADB proprietors rather than receiving a Government Furnished Information (GFI) version of the SADB. They also indicated that since the framework and tools appeared to apply to Major Defense Acquisition Programs (MDAPs), we should extend the scope from weapons platforms to MDAPs. We revised our plans accordingly, along with accommodating the no-cost extension of the task to 30 September 2009.

2. Initial Key Activities

Our initial key activities included creating a revised list of candidate EMs to evaluate; adding a Personnel Competency EM; reassigning the MIT evaluations.

Given the focus on Weapons Platforms, discussions with our initial sponsors and with developers of candidate EMs, and additional candidate EMs that emerged since the proposal, we added three promising candidate EMs. To balance the workload and to focus our work on the strongest and most-relevant EMs, we also dropped five less-strong or less-relevant candidate EMs that were in our proposal. Below are the EM candidates added and dropped, with short comments on each.

At the January 29-30 workshop, our sponsor Nicholas Torelli requested that we add a candidate EM on Personnel Competency. Some prospective candidates were identified; USC evaluated each and mapped the results to an expanded EM performance framework. Given that MIT was unable to participate in the EM task, we reallocated its evaluation functions in the revised matrix, Table 11, and added funds for the remaining performers.

Candidates Added

- Air Force Probability of Program Success (PoPS) Framework. (https://acc.dau.mil/CommunityBrowser.aspx?id=24415)

A well-organized, thorough set of evaluation criteria in wide use in different versions by the Army, Navy, and Air Force. We used the Air Force version because it came to our attention first, and the others were similar.

- National Research Council Pre-Milestone A and Early-Phase Systems Engineering study Pre-Milestone A/B Checklist, The National Academies Press, 2008

Twenty questions well-correlated with the study's findings.

- Stevens Leading Indicators of Program Success and Failure Framework (charts by Mark Weitekamp and Dinesh Verma posted on the EM task collaboration site)

A set of critical success factors based on the SADB data and Program Support Team Leader (PSTL) interviews.

- Personnel Competency EM

Primary candidates were the International Council on Systems Engineering (INCOSE) Systems Engineering Certification criteria and a candidate framework identified by Dr. Ken Nidiffer of Carnegie-Mellon University / Software Engineering Institute (CMU/SEI). At the INCOSE Workshop on

February 1, the INCOSE leads for the INCOSE Systems Engineering Certification criteria agreed to collaborate in providing their framework. Dr. Nidiffer arranged for similar access to the other framework.

Candidates Dropped

- IBM-Stevens Complexity Point paradigm (Barker-Verma, 2003)

More focused on cost estimation; limited number of EMs.

- USC-MIT COSYSMO Cost Drivers and Risk Analyzer (Madachy and Valerdi, 2007)

More focused on cost estimation; EMs mostly covered by other candidates.

- USC Award Fee Criteria for Spiral Developments (Reifer-Boehm, 2006)

More focused on system of systems acquisition; EMs mostly covered by other candidates.

- DAU-Fraunhofer Center Best Practices Repository (Shull and Turner, 2005)

EMs largely keywords; most covered by other candidates.

- NUWC Open System Engineering Effectiveness Measurement (Kowalski et al., 1998)

Focused mostly on an aspect of net-centric services; somewhat dated.

Table 11. Revised EM Evaluation Assignments

Candidate EM	USC	Stevens	FC-MD	UAH
PoPS Leading Indicators (LIs)	X	X		X
INCOSE LIs	X		X	
Stevens LIs	X	X	X	
SISAIG LIs	X		X	X
NRC List	X		X	X
SEI-CMMI	X	X		X
USC AP-Feasibility	X	X	X	
UAH Team Effectiveness	X	X		X

Pers. Competency	X			X

3. Project Schedule

On January 9, we had an EM task planning review activity in which we rebaselined the proposed schedule for performing and coordinating the EM task. The primary changes from the December 20 Version 2 were to add specific survey/interview and coverage matrix deliverables; to change the January 29-30 workshop to a SERC-internal teams-and-collaborators workshop on interim results; to have a SERC-external workshop proposed for the March 30-April 3 week in the District of Columbia (DC) area on the EM recommendations for pilot evaluation; to have a piloting readiness review in the DC area May 6-7, and to have a single round of pilot evaluations between May 11 and July 10.

At the January 29-30 workshop, we converged on March 31-April 1 as the dates for the next workshop. We adjusted the subtask times to avoid known conflicts with holidays or major conferences and to capitalize on neighboring systems engineering community events.

With respect to weekly and monthly battle rhythms, we converged on Fridays 11 AM – noon Eastern Standard Time / 8–9 AM Pacific Standard Time for both weekly tag-ups and monthly sponsor progress reports, with the EM task doing the first 30 minutes and the MPT task the second 30 minutes. At the May 7 meeting, the sponsors indicated that they would have Chris Miller participate in the weekly meetings instead of having monthly sponsor progress reports.

The May 6 workshop identified several improvements that would be needed to make the prototype Systems Engineering Performance Risk Tool (SEPRT) and Systems Engineering Competency Risk Tool (SECRT) ready for piloting. We rescheduled the pilots to start in June, and moved back the analysis of the pilots and pre-delivery workshop to fit within the extended completion date of September 30. The September workshop date was approximate, based on sponsor availability. It was later adjusted to September 8.

Table 12. EM Task Schedule and Results

Period	Activity	Results
12/8/08 – 1/28/09	Candidate EM assessments, surveys, interviews, coverage matrix	Initial survey results, candidate EM assessments, coverage matrix
1/29/09 – 30/09	SERC-internal joint workshop with Methods, Processes, and Tools (MPT)	Progress report on results, gaps, plans for gap follow-ups
2/1/09 – 3/27/09	Sponsor feedback on results and plans; sponsor identification of candidate pilot organizations; execution of plans; suggested EMs for weapons platform (WP) pilots	Identification of WP pilot candidate organizations at Contractor, PEO-PM. Oversight levels; updated survey, EM evaluation, recommended EM results

3/31/09 – 4/1/09	SERC-external joint workshop with MPT, sponsors, collaborators, pilot candidates, potential EM users	Guidance for refining recommended; EMs; candidates for pilot EM; evaluations
4/7/09 – 5/1/09	Tailor lead EM candidates for WP pilots; SADB-based; evaluations of candidate EMs	Refined, tailored EM candidates for WP pilots at contractor, PEO-PM, oversight levels; pilot evaluation guidelines
5/6/09	Workshop with sponsors, collaborators, pilot candidates, stakeholders; select WP EM pilots	Selected pilots; guidance for final preparation of EM candidates and evaluation guidelines
5/11/09 – 6/12/09	Revise EM tools based on feed back; prepare pilot users' guide; Line up pilot projects	Most pilots ready to begin experimental use; some completing preparations
6/15/09 – 8/14/09	EM pilot experiments; analysis; and evaluation of guidelines and results; refinement of initial SADB evaluation; results based on EM improvements	EM pilot experience database and survey results; refined SADB EM evaluations
8/17/09 – 9/14/09	Analyze EM pilot and SADB results; prepare draft report on results, conclusions, and recommendations	Draft report on general EM evaluation results, conclusions, and recommendations for usage and research/transition/education initiatives
9/15/09	Workshop on draft report with sponsors, collaborators, EM evaluators, stakeholders	Feedback on draft report results, conclusions, and recommendations
9/16/09 – 9/30/09	Prepare, present, and deliver final report	Final report on MDAP EM evaluation results, conclusions, and recommendations for usage and research/transition/education initiatives

APPENDIX H. COMPARISON OF SECRT AND DAU SPRDE-SE/PSE COMPETENCY MODEL

Another personnel competency framework that has been suggested for comparison to the SECRT framework is the Defense Acquisition University's SPRDE-SE/PSE Competency Model. This Appendix provides a mapping between the SECRT and the SPRDE-SE/PSE frameworks. It concludes that there are differences in organization, terminology, and detail, but that they are largely consistent in terms of overall content coverage.

The main topics that are covered by the SPRDE-SE/PSE Competency Model and are not well covered by the SECRT are Elements 3, 16, and 17-18 on Safety Assurance, System Assurance, and Reliability, Availability, and Maintainability (assumed by SECRT to be covered by complementary domain-specific extensions); Element 20 on Technical Data Management (not emphasized in the 8 DoD SE source documents analyzed in preparing the SECRT); and Elements 37-38 and 39 on manufacturing and logistics management (deferred by initial SECRT emphasis on early SE risk assessment.

The main topics that are covered by the SECRT and are not well covered by the SPRDE-SE/PSE Competency Model are Elements 2.4 on Source Selection Support; 5.2 on Collaboration; and 5.5 on Adaptability and Learning.

SPRDE-SE/PSE Competency Model
Unit of Competence: Analytical

#	Competency	Element Description
1	Technical Basis for Cost	Element 1. Provide technical basis for comprehensive cost estimates and program budgets that reflect program phase requirements and best practices using knowledge of cost drivers, risk factors, and historical documentation (e.g. hardware, operational software, lab/support software). Maps to SECRT 1.3 (a), 2.3 (a), 3.4 (a-e)
2	Modeling and Simulation	Element 2. Develop, use, and/or interpret modeling or simulation in support of systems acquisition. Maps to SECRT 1.1 (c). 3.3 (a-d)
3	Safety Assurance	Element 3. Review Safety Assurance artifacts to determine if the necessary SE design goals and requirements were met for: Safe For Intended Use (SFIU), warfighter survivability, user safety, software safety, environmental safety, Programmatic Environmental, Safety and Health Evaluations (PESHE), and/or Critical Safety applications. Maps to SECRT 3.1 (b), 3.2 (b,c) in general. Can be made more specific with a safety-domain extension
4	Stakeholder Requirements Definition	Element 4. Work with the user to establish and refine operational needs, attributes, performance parameters, and constraints that flow from the Joint Capability Integration and Development System (JCIDS) described capabilities, and ensure all relevant requirements and design considerations are addressed. Maps to SECRT 1.1 (a-e), 1.3 (a-c)
5	Requirements Analysis	Element 5. Ensure the requirements derived from the customer-designated capabilities are analyzed, decomposed, functionally detailed across the entire system, feasible and effective. Maps to SECRT 1.4 (a-c), 3.2 (a-c)

6	Architecture Design	Element 6. Translate the outputs of the Stakeholder Requirements Definition and Requirements Analysis processes into alternative design solutions. The alternative design solutions include hardware, software, and human elements; their enabling processes; and related internal and external interfaces. Maps to SECRT 1.2 (a-d), 1.3 (a-c), 2.5 (a), 3.1 (a-e)
		Element 7. Track and manage design considerations (boundaries, interfaces, standards, available production process capabilities, performance and behavior characteristics) to ensure they are properly addressed in the technical baselines. Maps to SECRT 1.3 (a,b), 1.4 (a-c)
		Element 8. Generate a final design or physical architecture based on reviews of alternative designs. Maps to SECRT 1.2 (a-d), 2.5 (a)
		Element 9. Conduct walkthroughs with stakeholders to ensure that requirements will be met and will deliver planned systems results under all combinations of design usage environments throughout the operational life of a system. Maps to SECRT 1.1 (a-e)
7	Implementation	Element 10. Manage the design requirements and plan for corrective action for any discovered hardware and software deficiencies. Maps to SECRT 4.1 (a-c), 4.2 (a-c)
8	Integration	Element 11. Manage the technical issues that arise as a result of the integration processes that feed back into the design solution process for the refinement of the design. Maps to SECRT 4.2 (a-c)
9	Verification	Element 12. Design and implement a testing process to compare a system against required system capabilities, to link Modeling and Simulation (M&S), Developmental Test and Evaluation (DT&E) and Operational Test and Evaluation (OT&E) together, in order to document system capabilities, limitations, and risks. Maps to SECRT 4.1 (a,b)
		Element 13. Verify the system elements against their defined requirements (build-to specifications). Maps to SECRT 2.5 (d), 4.1 (a,b), 4.2 (a,b)
10	Validation	Element 14. Evaluate the requirements, functional and physical architectures, and the implementation to determine the right solution for the problem. Maps to SECRT1.3 (a,c)

11	Transition	Element 15. Advance the system elements to the next level in the physical architecture or provide the end item to the user after ensuring integration with other systems and interface management, both internal and external, for use in the operational environment. Maps to SECRT 2.2 (a-d) in the context of continuing evolutionary SE
12	System Assurance	Element 16. Apply and execute the appropriate systems engineering, software assurance, and certification-related policies, principles, and practices across all levels and phases of an acquisition program to increase the level of confidence that a system functions as intended, is free from exploitable vulnerabilities, and protects critical program information. Maps to SECRT3.1 (b), 3.2 (b,c) in general. Can be made more specific with an assurance-domain extension
13	Reliability, Availability & Maintainability (RAM)	Element 17. Manage the contributions to system RAM that are made by hardware, software, and human elements of the system. Maps to SECRT 3.2 (a-c) in general. Can be made more specific with a RAM-domain extension
		Element 18. Evaluate the RAM of systems, including the following: Maintenance Engineering/Sustaining Engineering review and assessment; considerations of different use environments, operators, and maintainers; and the monitoring of performance versus predictions of performance. Maps to SECRT 3.2 (a-c), 3.4 (a) in general. Can be made more specific with a RAM-domain extension

Unit of Competence: Technical Management

#	Competency	Element Description
14	Decision Analysis	Element 19. Employ procedures, methods, and tools for identifying, representing, and formally assessing the important aspects of alternative decisions (options) to select an optimum (i.e., the best possible) decision. Maps to SECRT 1.2 (a-d), 4.5 (a-c)
15	Technical Planning	Element 20. Address the scope of the technical effort required to develop, field, and sustain the system using the mandated tool, the Systems Engineering Plan. Maps to SECRT 2.3 (a-d), 3.4 (a-d)

16	Technical Assessment	Element 21. Develop and/or use Technical Assessment metrics (i.e., Technical Performance Measures, Measures of Effectiveness, requirements compliance, and risk assessments) to measure technical progress, review life-cycle costs, and assess the effectiveness of plans and requirements. Maps to SECRT 1.2 (a-d), 2.5 (d), 3.2 (a-c), 3.3 (a-d), 3.4 (a-d)
17	Configuration Management	Element 22. Apply sound program practices to establish and maintain consistency of a product or system's attributes with its requirements and evolving technical baseline over its life-cycle. Maps to SECRT 4.3 (a-e)
18	Requirements Management	Element 23. Use Requirements Management to trace back to user-defined capabilities and other sources of requirements, and to document all changes and the rationale for those changes. Maps to SECRT 4.3 (a-e)
19	Risk Management	Element 24. Create and implement a Risk Management Plan encompassing risk identification, analysis, mitigation planning, mitigation plan implementation, and tracking throughout the total life-cycle of the program. Maps to SECRT 2.2 (a,c,d), 4.4 (a,b), 4.5 (c)
		Element 25. Apply risk management at the earliest stages of program planning and continue throughout the total life cycle of the program through the identification of risk drivers, dependencies, root causes, and consequence management. Maps to SECRT 1.4 (c), 2.2 (a,c,d), 4.4 (a,b), 4.5 (b,c)
20	Technical Data Management	Element 26. Apply policies, procedures and information technology to plan for, acquire, access, manage, protect, and use data of a technical nature to support the total life cycle of the system. Not covered; was not mentioned in 8 DoD SE EM source documents
21	Interface Management	Element 27. Ensure interface definition and compliance among the elements that compose the system, as well as with other systems with which the system or system elements will interoperate (i.e., system-of-systems (SoS)) by implementing interface management control measures to ensure all internal and external interface requirement changes are properly documented in accordance with the configuration management plan and communicated to all affected configuration items. Maps to SECRT 1.3 (b), 3.1 (c), 3.2 (a,b), 4.3 (a-c)

		Element 28. Evaluate how Interface Management techniques ensure that all internal and external interface changes in requirements are properly documented and communicated in accordance with the configuration management plan. Not well covered. Indirect mapping to SECRT 4.3 (e)
22	Software Engineering	Element 29. Software Measures - Use quantitative methods to assess and track software progress against a baseline (planned vs. actual) and provide status updates in order to make timely program decisions. Maps to SECRT 4.1 (a-c), 4.2 (a-c). These address measurement more generally
		Element 30. Integration of Software and Systems Engineering - Integrate essential acquisition and sustainment activities related to software through the use of multidisciplinary teams to optimize design, manufacturing, and supportability processes. Maps to SECRT 3.2 (a-c)
		Element 31. Software Impact on Acquisition Strategy - Determine software-related considerations and risks that must be addressed as part of the system acquisition strategy. Maps to SECRT 1.4 (c), 2.2 (a,c,d), 4.4 (a,b), 4.5 (b,c). These address risk more generally
		Element 32. Software Requirements - Evaluate inputs from relevant stakeholders that translate into functional and technical requirements that are documented, managed, traceable and verifiable through the software life-cycle process and describe the desired behavior of the software system to be built to satisfy the intended user(s). Maps to SECRT 1.4 (a-c), 3.2 (a-c)
		Element 33. Software Architecture - Understand the software structure of the system, including the definition of software components, and the relationships between software components, the system, and the operational architectures. Maps to SECRT 1.2 (a-d), 2.5 (a), 3.2 (a-c). These address architcture more generally
23	Acquisition	Element 34. Determine the appropriate amount of systems engineering and the resources needed during each acquisition phase to achieve acceptable levels of risk for entry into the next acquisition phase. Maps to SECRT 3.4 (a-d). These address resources needed more generally

		Element 35. Assess the proposed solution’s operational viability and costs of alternative systems during the Materiel Solution Analysis (formerly called Concept Refinement) Phase, taking into account the design considerations to achieve a balanced system design. Maps to SECRT 1.3 (a), 3.4 (a-d)
		Element 36. During the Technology Development Phase, integrate proven technologies, develop new hardware/software prototypes, evaluate solutions, and determine performance requirements to ensure that the cost, schedule, and other constraints are met and that risks are reduced. Maps to SECRT 3.3 (a-d), 3.4 (a-d)
		Element 37. Integrate hardware, software, and human systems, protect critical program information, ensure safety and affordability, and reduce manufacturing risks during the Engineering and Manufacturing Development (formerly called System Development and Demonstration) Phase to demonstrate supportability and interoperability within incremental stages of system development. Maps to SECRT 4.1 (a-c), 4.2 (a-c), 4.5 (a-c), although these focus more on early SE
		Element 38. Apply a Low-Rate Initial Production approach to attain Initial Operational Capability and Full-Rate Production and Deployment, considering Diminishing Manufacturing Sources and Material Shortages (DMSMS); assess changes in the design of manufacturing processes, and apply continuous testing and evaluation practices during the Production and Deployment Phase to reveal manufacturing and production problems and ensure continuous enhancements to the product. Maps to SECRT 4.1 (a-c), 4.5 (a-c), although these are much more focused on early SE
		Element 39. Plan the Logistics Management system manpower needs and support plans, and apply within a Performance-Based Logistics (PBL) environment, for the full system life-cycle, to ensure effective use of the system. Maps to SECRT 4.1 (a-c), 4.5 (a-c), although these are much more focused on early SE
24	Systems Engineering Leadership	Element 40. Lead teams by providing proactive and technical direction and motivation to ensure the proper application of systems engineering processes and the overall success of the technical management process. Maps to SECRT 5.3 (a-c)

25	System of Systems	Element 41. Oversee the planning, analyzing, organizing, and integrating the capabilities of a mix of existing and new systems into an SoS capability greater than the sum of the capabilities of the constituent parts. SoS engineering is an activity that spans the entire system's life cycle; from pre-Milestone A through Disposal. Maps to SECRT 1.3 (a-c), 2.1 (a-c), 2.2 (a-d), 4.3 (a-e). These address systems more generally
Unit of Competence: Professional		
#	**Competency**	**Element Description**
26	Communication	Element 42. Communicate technical and complex concepts in a clear and organized manner, both verbally and in writing, to inform and persuade others to adopt and act on specific ideas. Maps to SECRT 5.3 (a-c)
27	Problem Solving	Element 43. Make recommendations using technical knowledge and experience, developing a clear understanding of the system, identifying and analyzing problems using a Total Systems approach, weighing the relevance and accuracy of information, accounting for interdependencies, and evaluating alternative solutions. Maps to SECRT 2.5 (a-c)
28	Strategic Thinking	Element 44. Formulate and ensure the fulfillment of objectives, priorities, and plans consistent with the long-term business and competitive interests of the organization in a global environment. Maps to SECRT 2.5 (a-c).
29	Professional Ethics	Element 45. Maintain strict compliance to governing ethics and standards of conduct in engineering and business practices to ensure integrity across the acquisition life-cycle. Maps to SECRT 5.4 (a,b)
30	Missing	SECRT also includes 2.4, Source Selection Support, 5.2, Collaboration, and 5.5, Adaptability and Learning